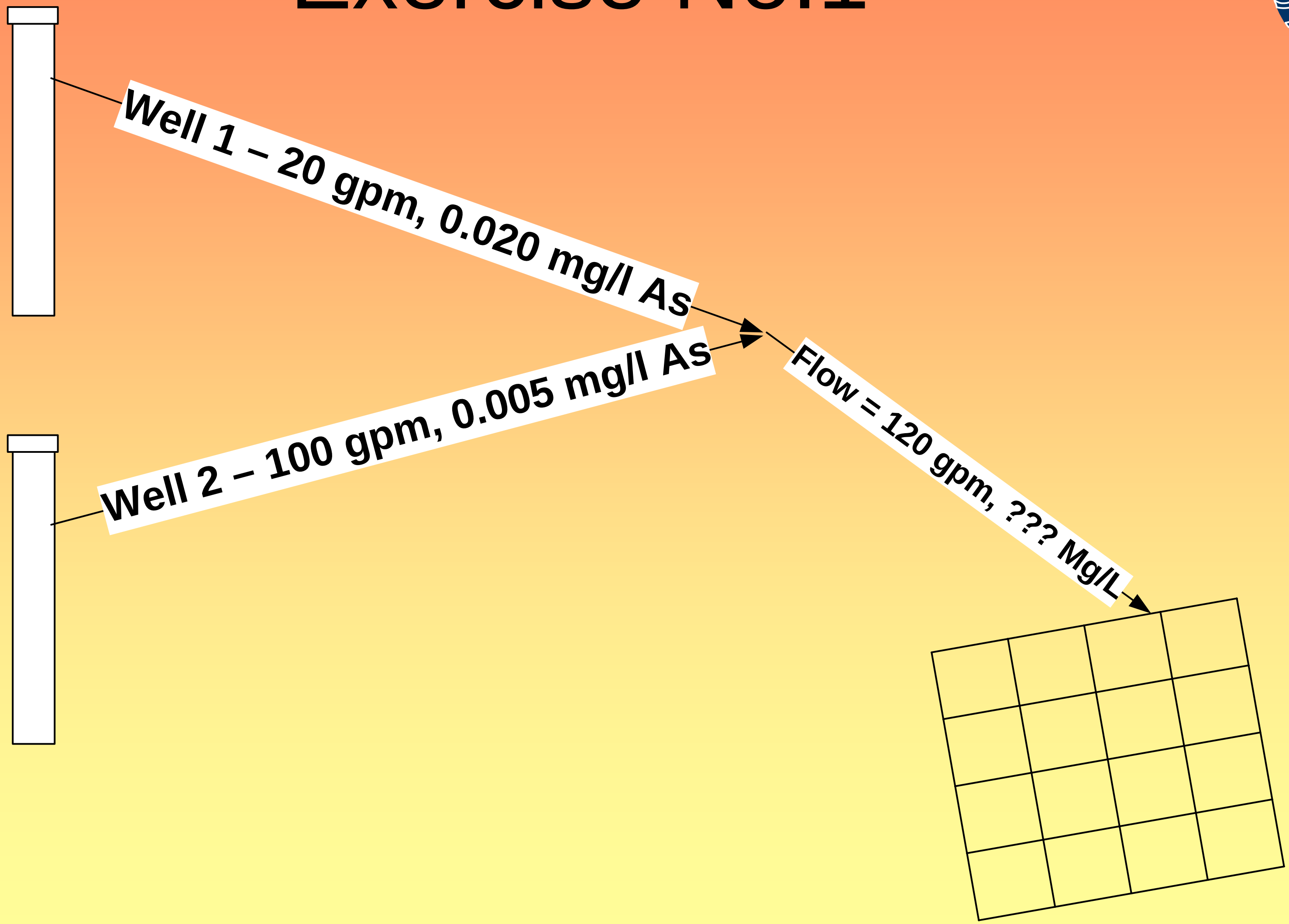
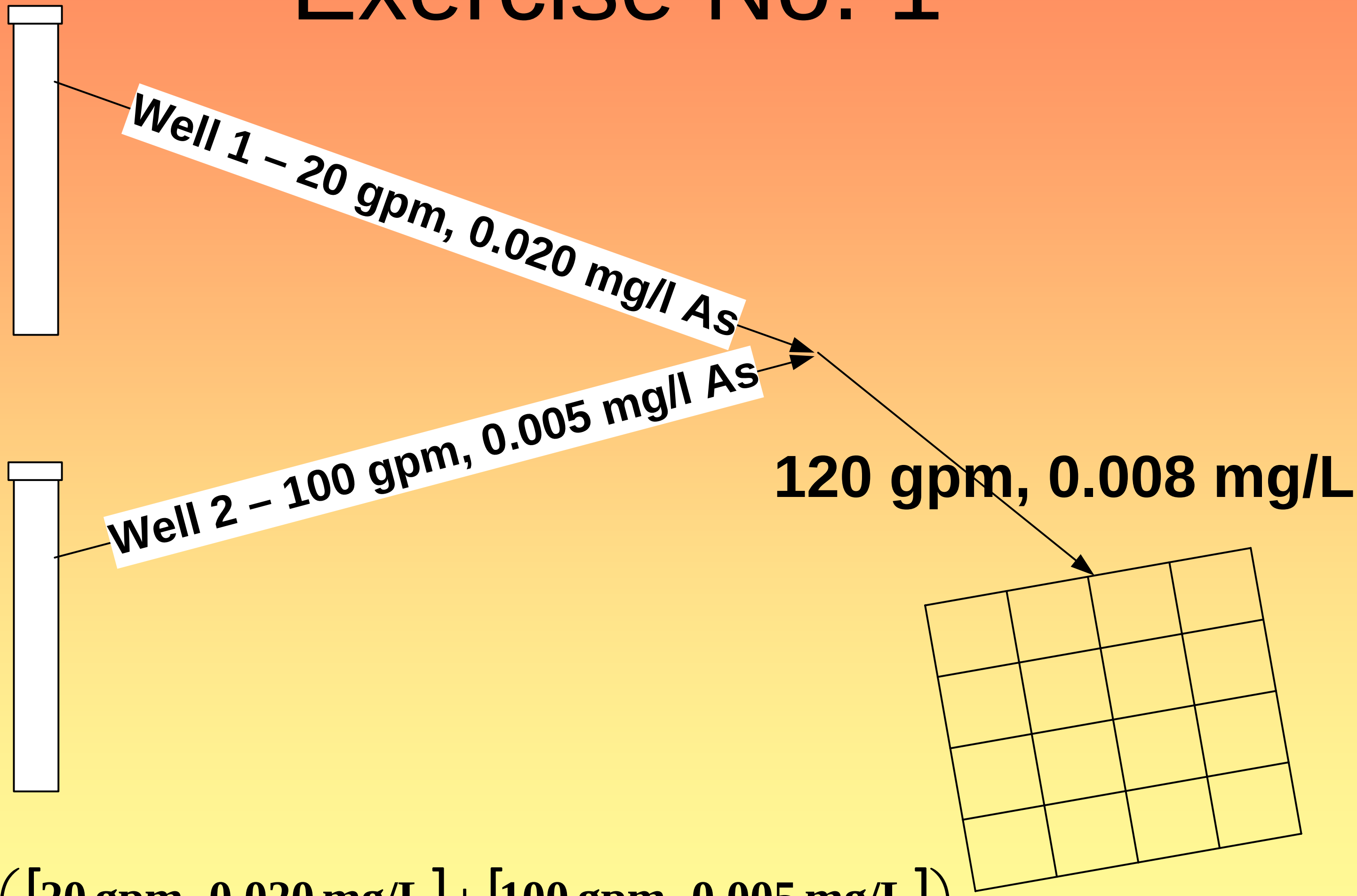
Treatment Decision Exercises

Blending With No Treatment
Exercise No.1

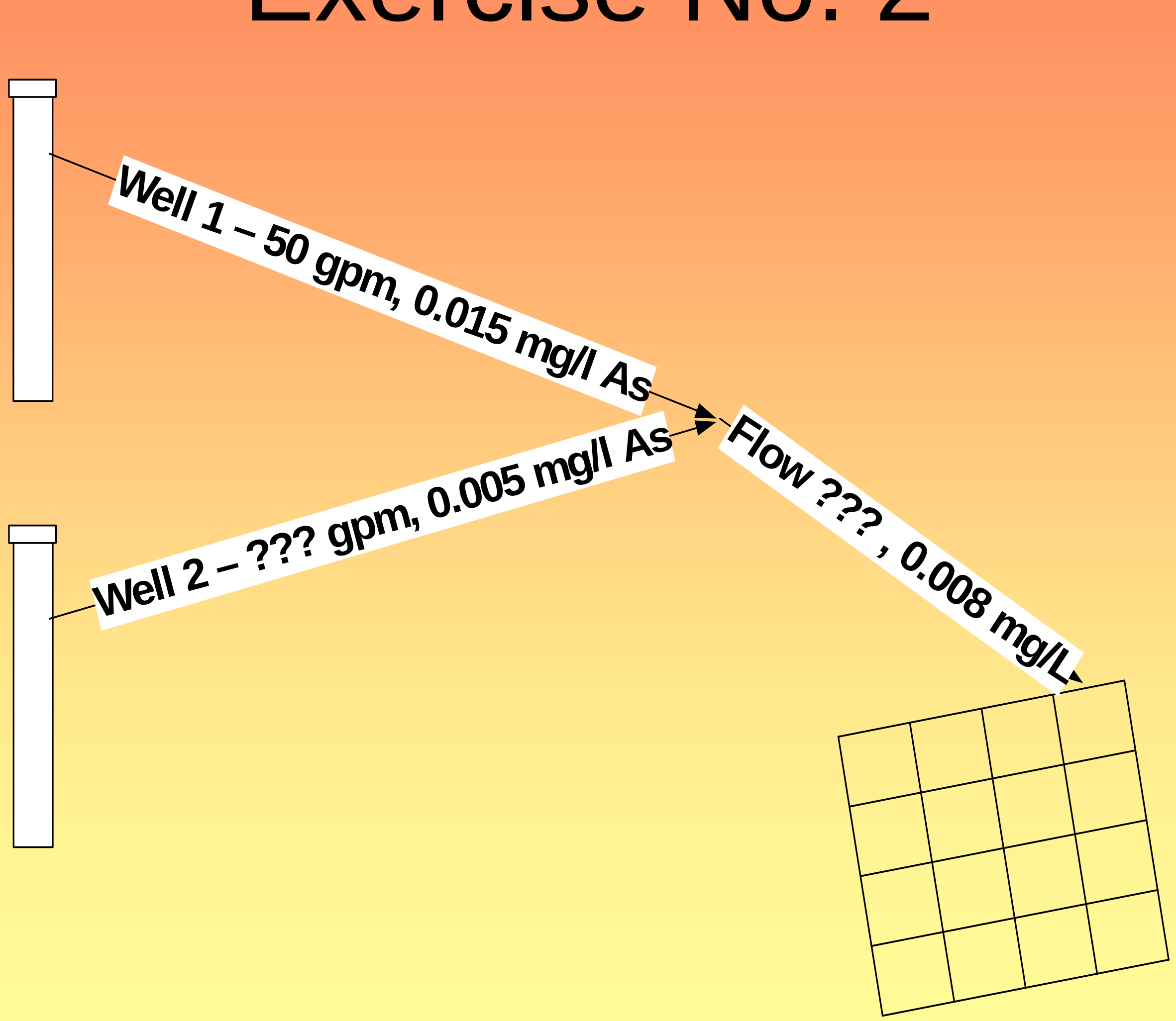


Blending With No Treatment Exercise No. 1

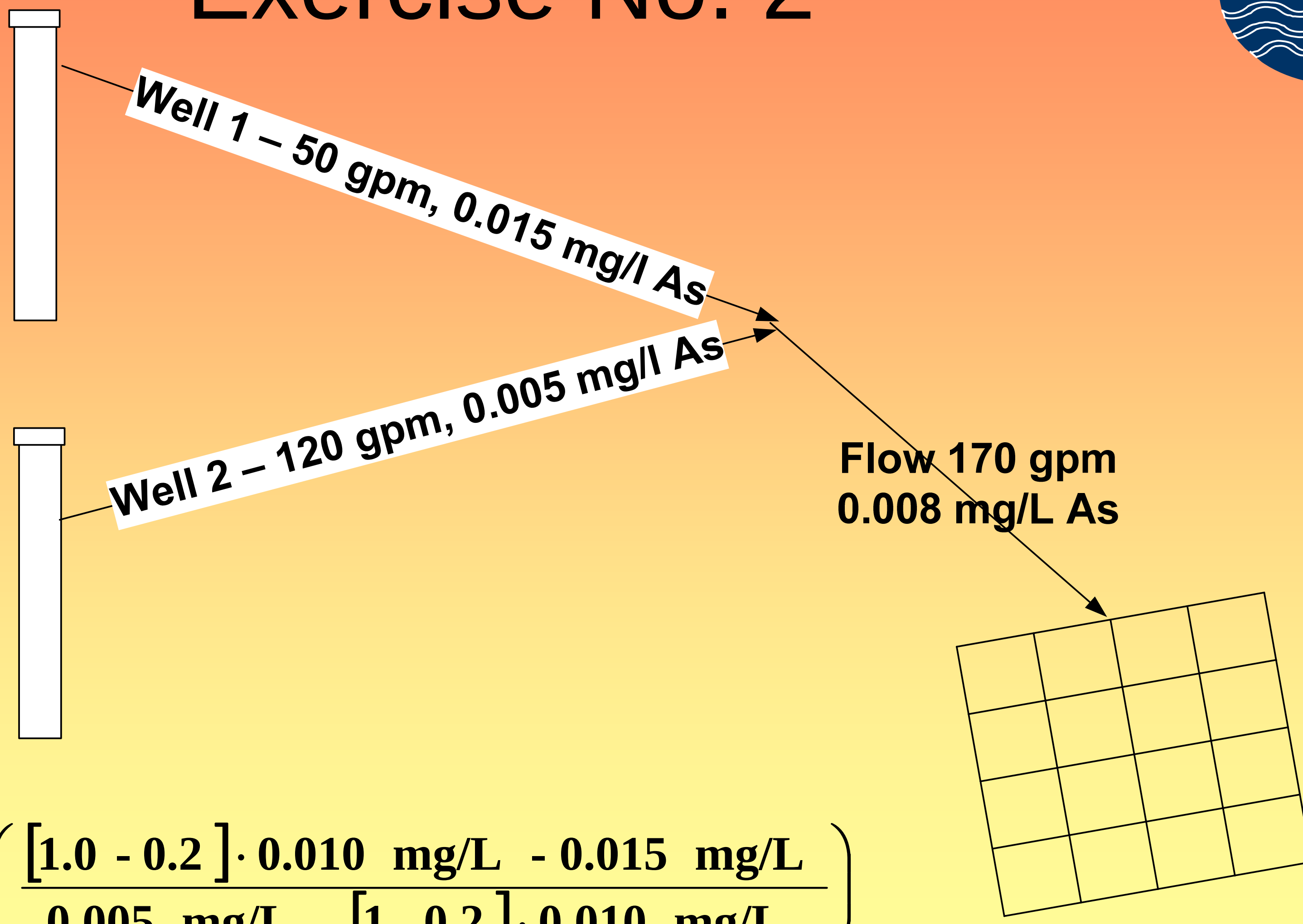


$$C_{As,B} = \left(\frac{[20\,\mathrm{gpm} \cdot 0.020\,\mathrm{mg/L}] + [100\,\mathrm{gpm} \cdot 0.005\,\mathrm{mg/L}]}{20\,\mathrm{gpm} + 100\,\mathrm{gpm}}\right)$$

Blending With No Treatment
Exercise No. 2

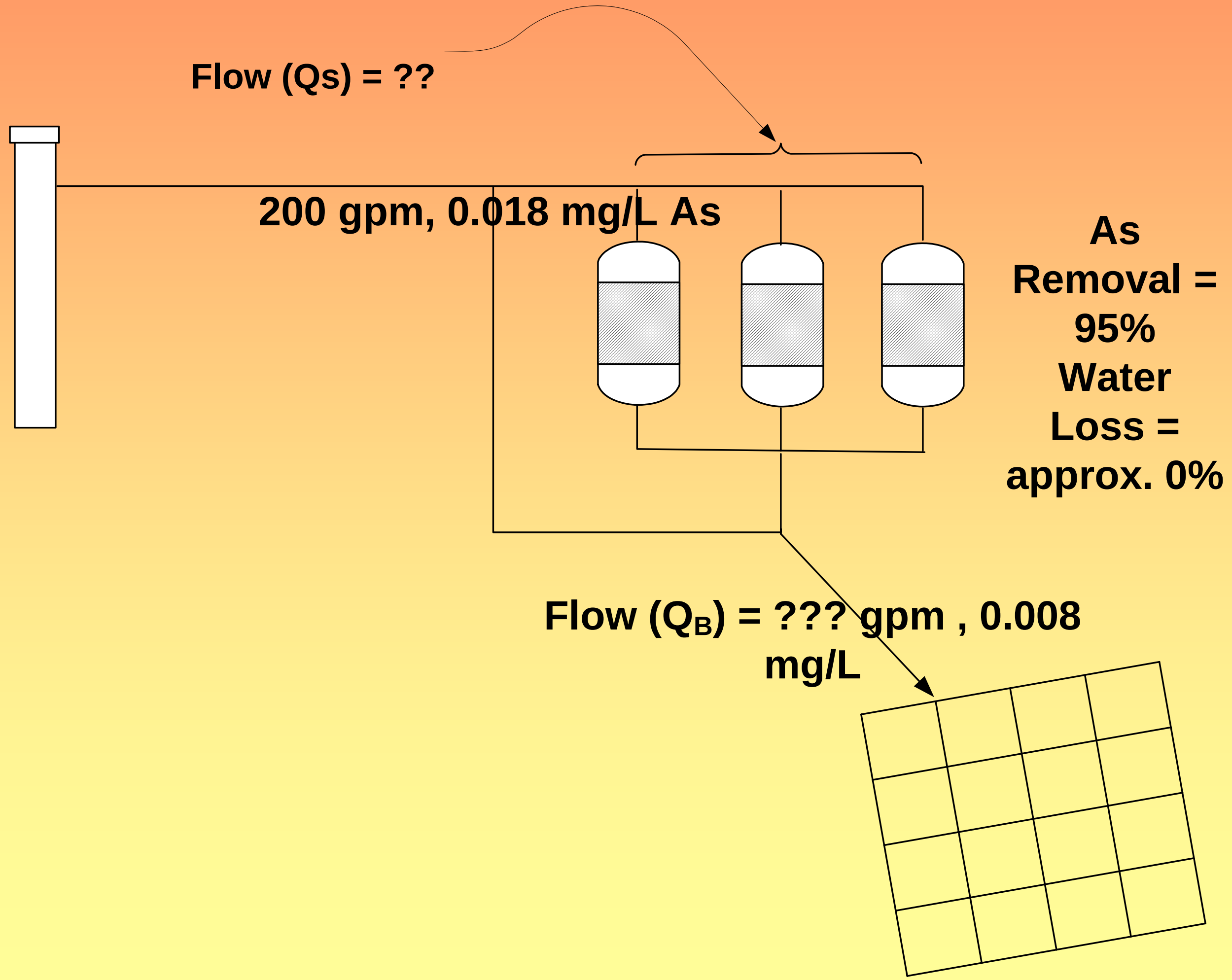


Blending With No Treatment
Exercise No. 2

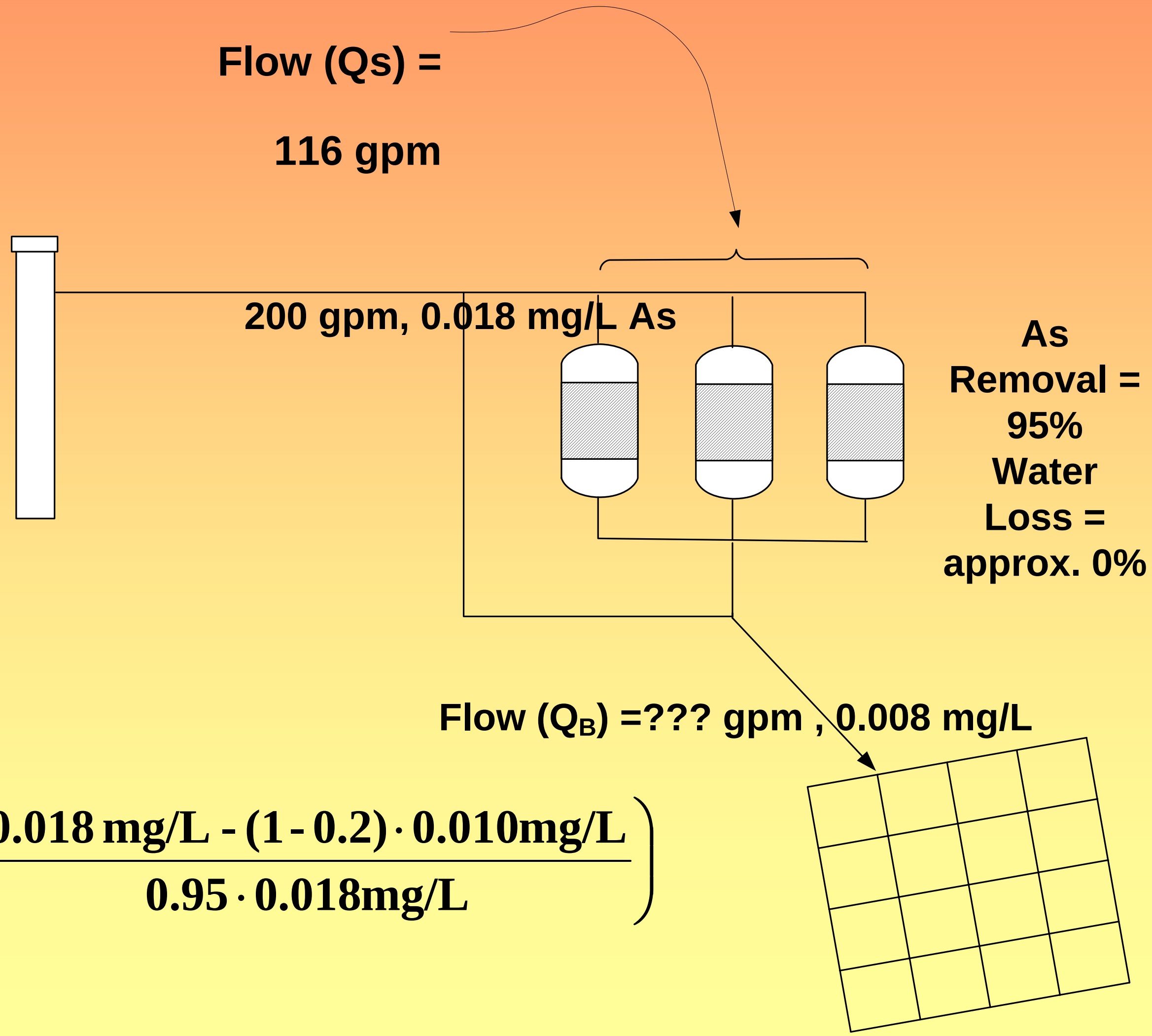


$$Q_2 = 50 \cdot \left(\frac{[1.0 - 0.2] \cdot 0.010 \text{ mg/L} - 0.015 \text{ mg/L}}{0.005 \text{ mg/L} - [1 - 0.2] \cdot 0.010 \text{ mg/L}} \right)$$

Sidestream Treatment with Blending Exercises No. 1

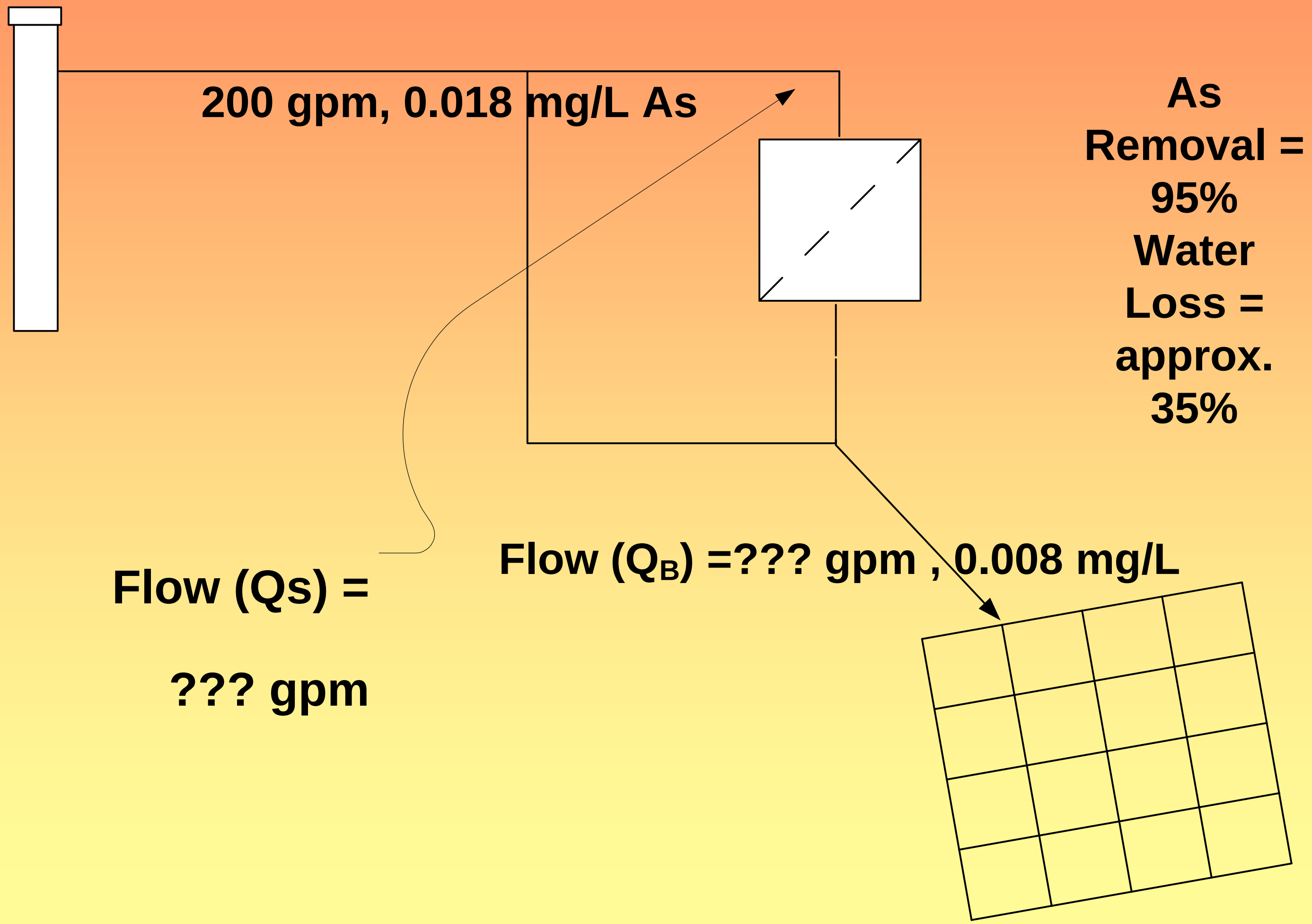


Sidestream Treatment with Blending Exercises No. 1

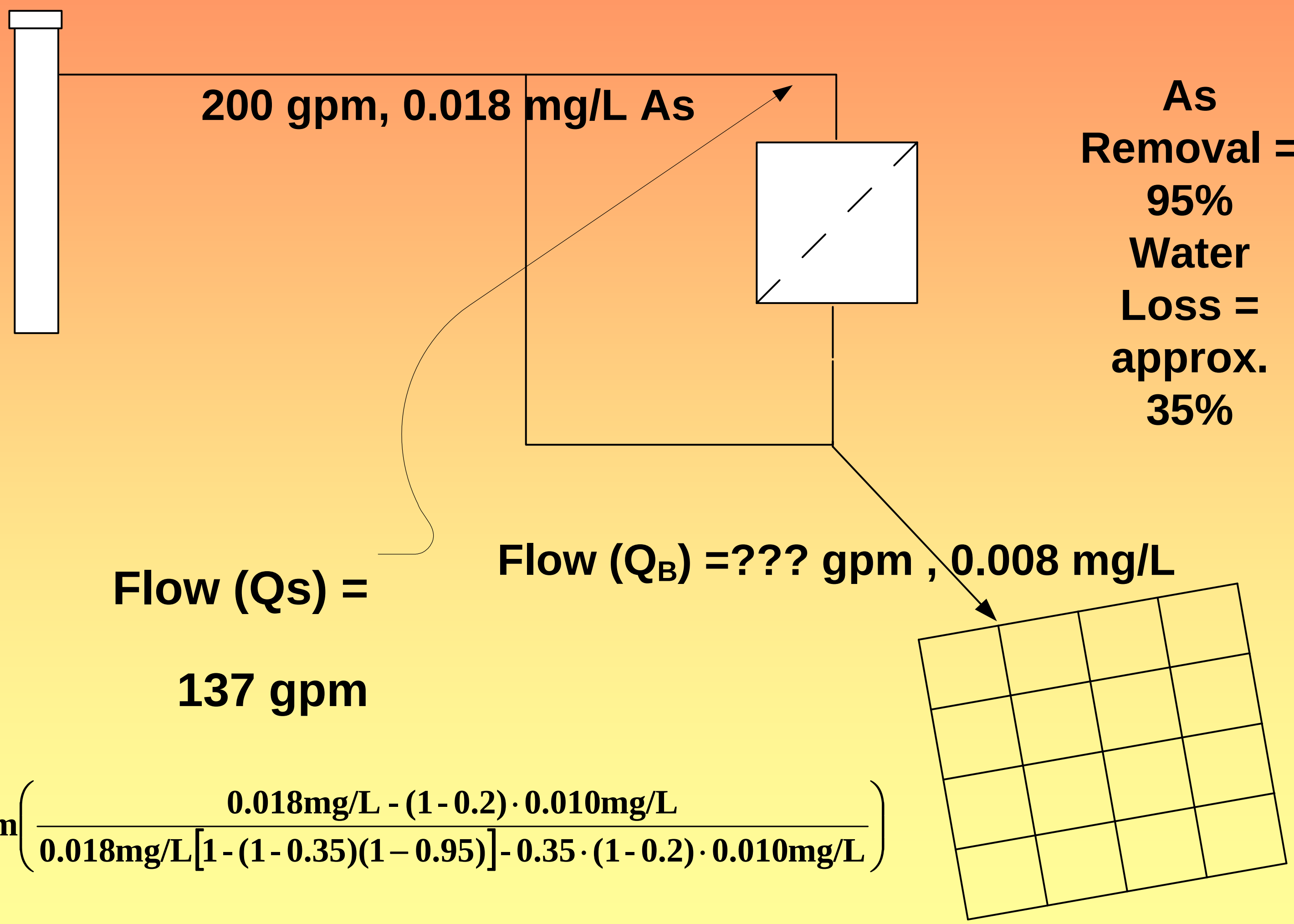


$$Q_S = 200\text{gpm}\left(\frac{0.018\ \text{mg/L} - (1-0.2)\cdot 0.010\text{mg/L}}{0.95\cdot 0.018\text{mg/L}}\right)$$

Sidestream Treatment with Blending Exercises No. 2



Sidestream Treatment with Blending Exercises No. 2



200 gpm, 0.018 mg/L As

As Removal = 95%

Water Loss = approx. 35%

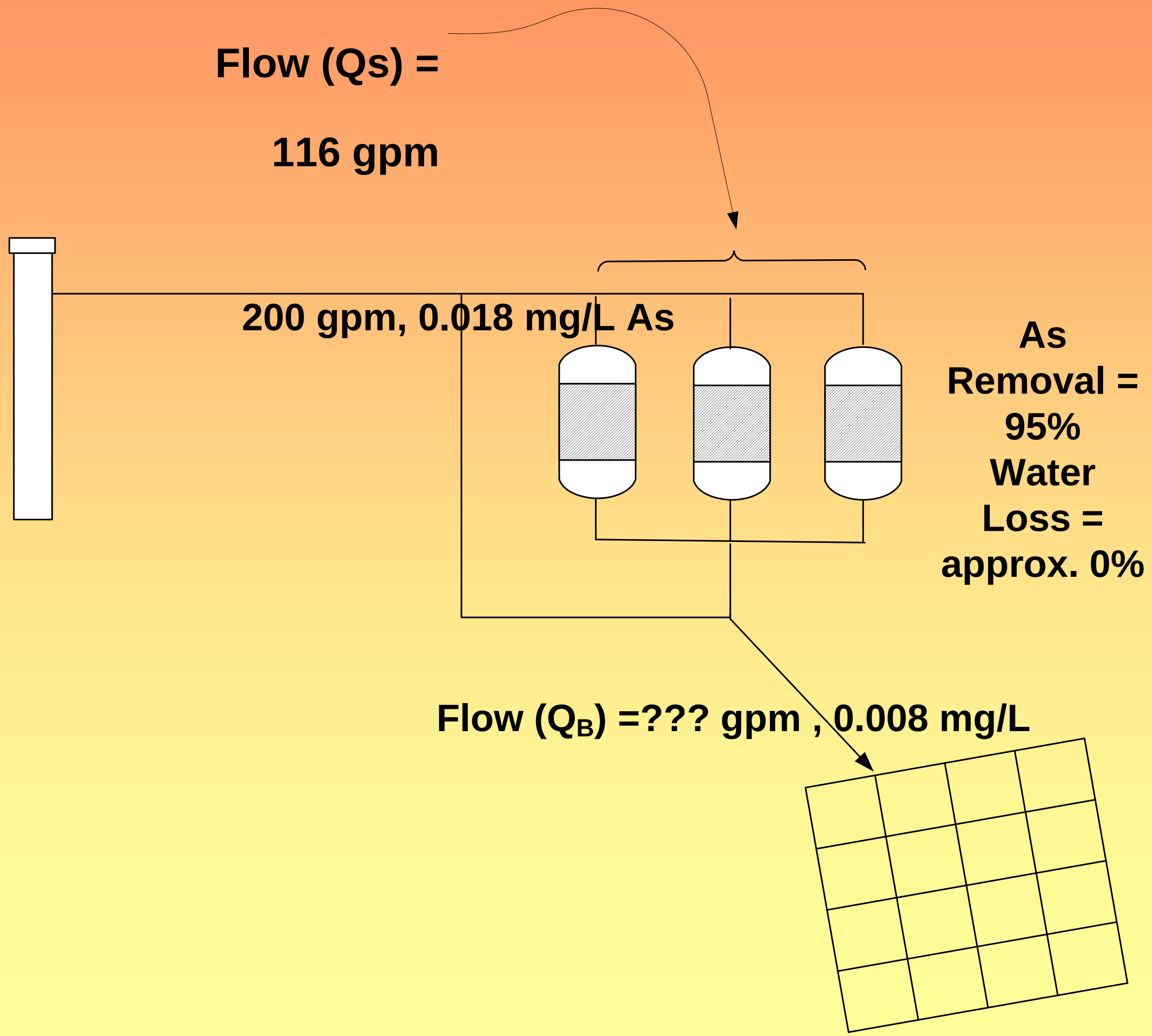
Flow (Q_B) =??? gpm , 0.008 mg/L

Flow (Qs) =

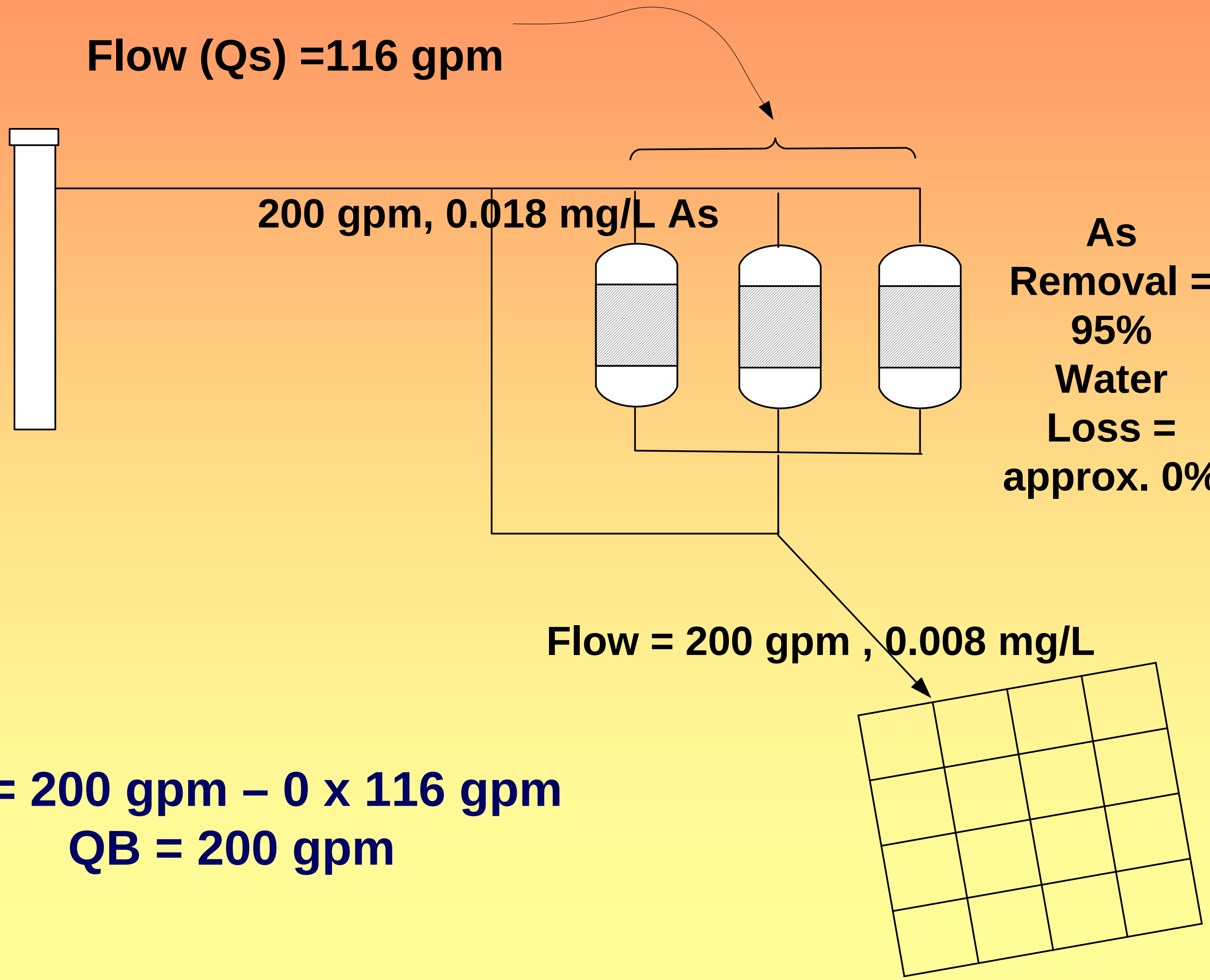
137 gpm

$$Q_S = 200\text{gpm}\left(\frac{0.018\text{mg/L} - (1-0.2)\cdot 0.010\text{mg/L}}{0.018\text{mg/L}\left[1-(1-0.35)(1-0.95)\right] - 0.35\cdot(1-0.2)\cdot 0.010\text{mg/L}}\right)$$

Sidestream Treatment with Blending Exercises No. 3 Ads.



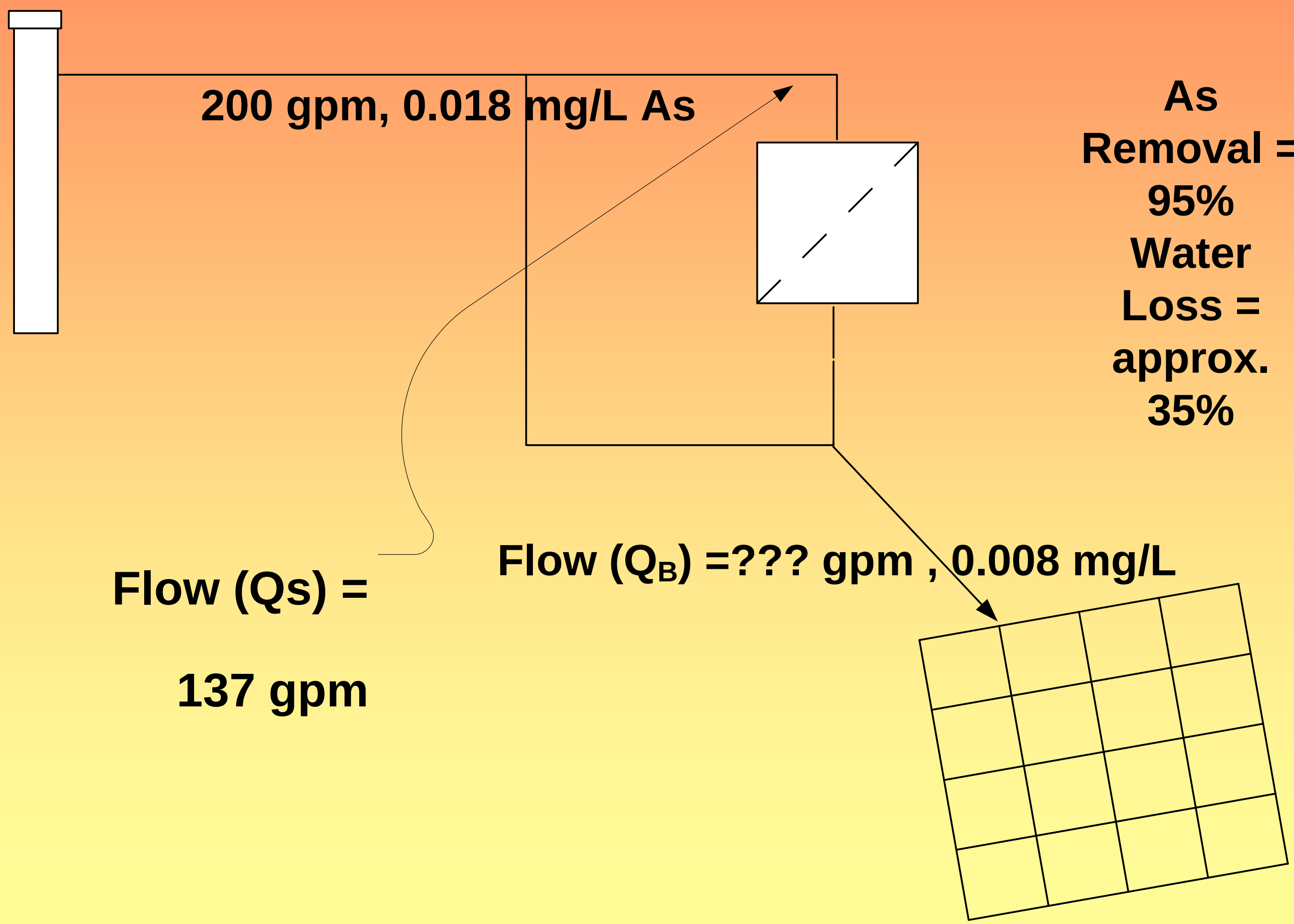
Sidestream Treatment with Blending Exercises No. 3 Ads.



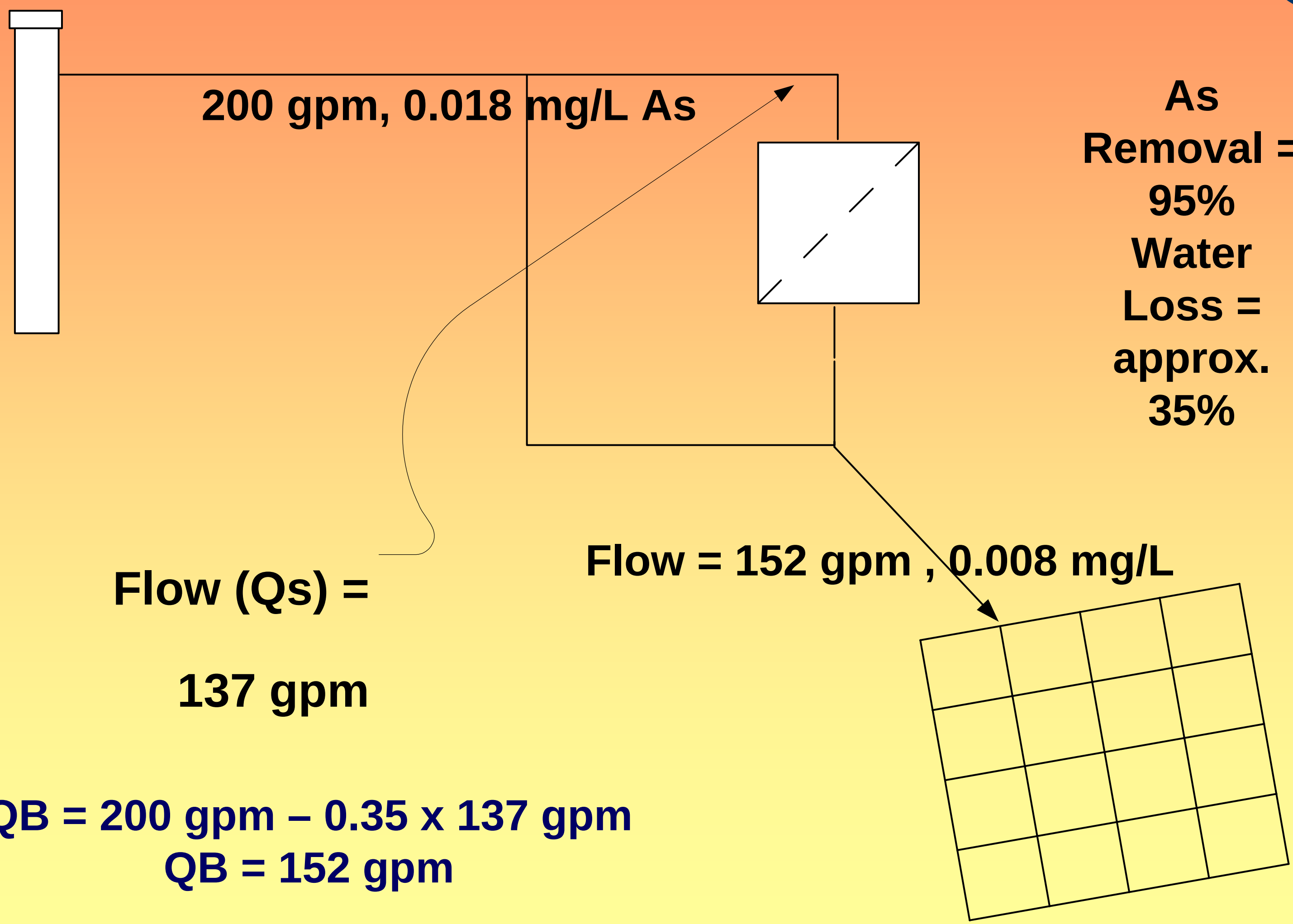
QB = 200 gpm – 0 x 116 gpm

QB = 200 gpm

Sidestream Treatment with Blending Exercises No. 3 RO



Sidestream Treatment with Blending Exercises No. 3 RO



QB = 200 gpm – 0.35 x 137 gpm
QB = 152 gpm

Sidestream Treatment with Blending Exercises No. 4

- RO flow = 152 gpm
  Ads flow = 200 gpm
- Consider water loss
- Consider other water quality problems
- Operator skill
- Waste generated
- Capital cost
- O & M cost

Facility A – Conventional treatment plant (alum) coagulation, dual-media filtration, backwash sludge lagoons, gravity storage

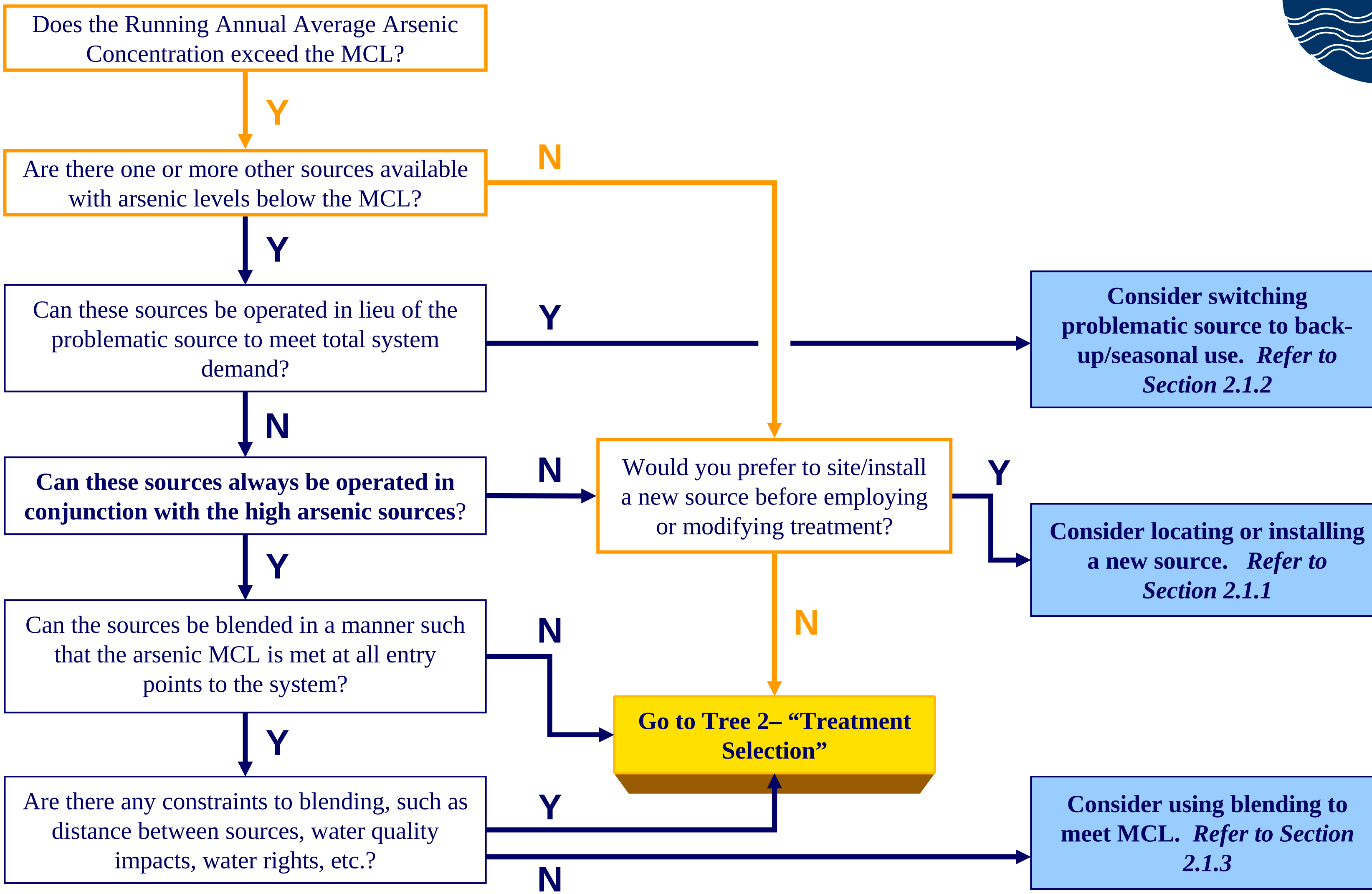
Population – 17,000

Maximum Daily Flow – 5 MGD: Single source

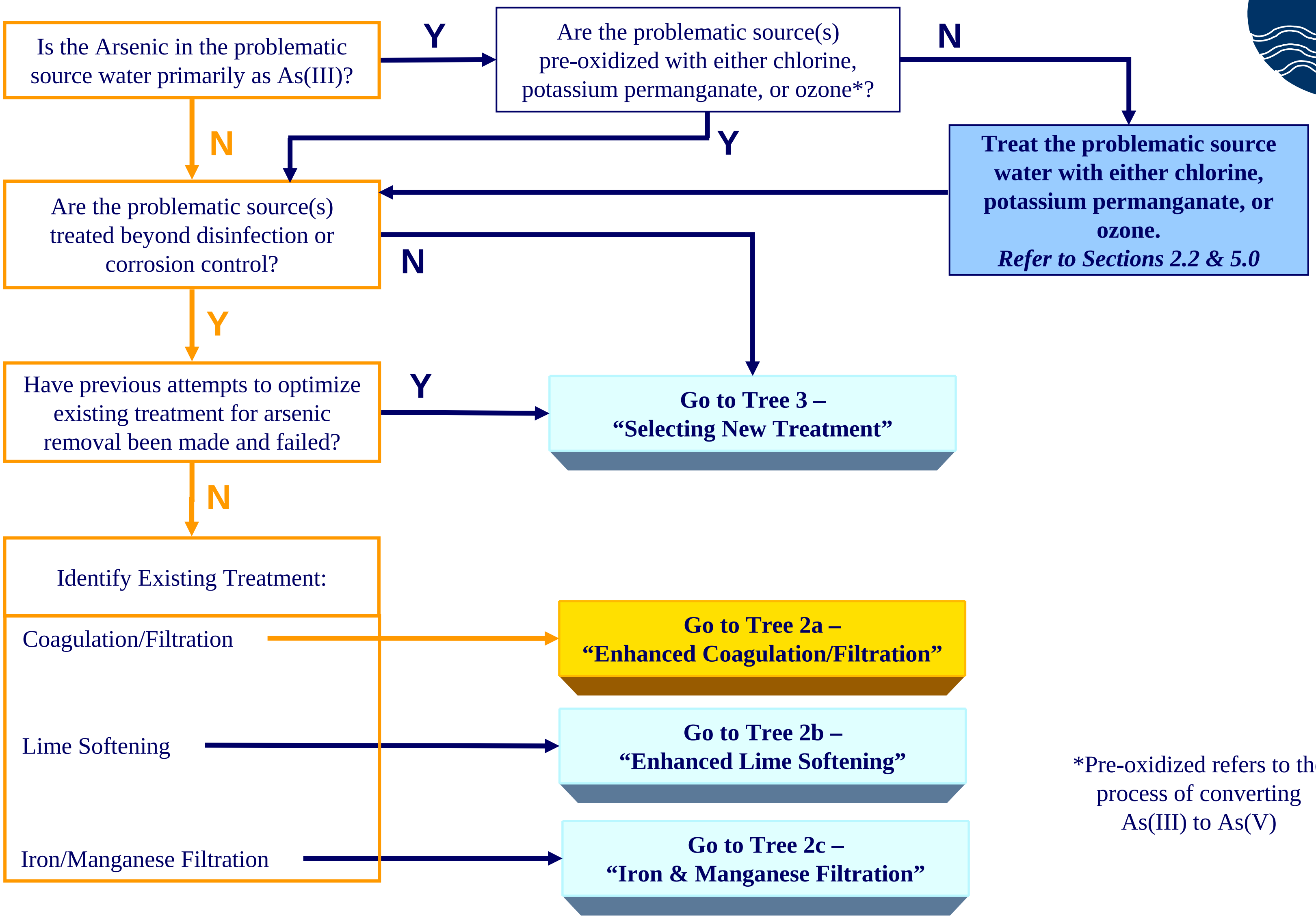
WQ Parameter	Value		WQ Parameter	Value
As µg/L – Total	23		NO_3 mg/L	0.3
As µg/L – V	23		NO_2 mg/L	<0.01
pH su	7.8		TOC mg/L	4
SO_4 mg/L	25		Si mg/L	20
Fe mg/L	1.2		Cl mg/L	23
Mn mg/L	na		F mg/L	<0.0
TDS mg/L	na		Alk – $CaCO_3$ mg/L	100

Misc: POTW discharge available, TBLLs imposed, landfill will not accept hazardous material

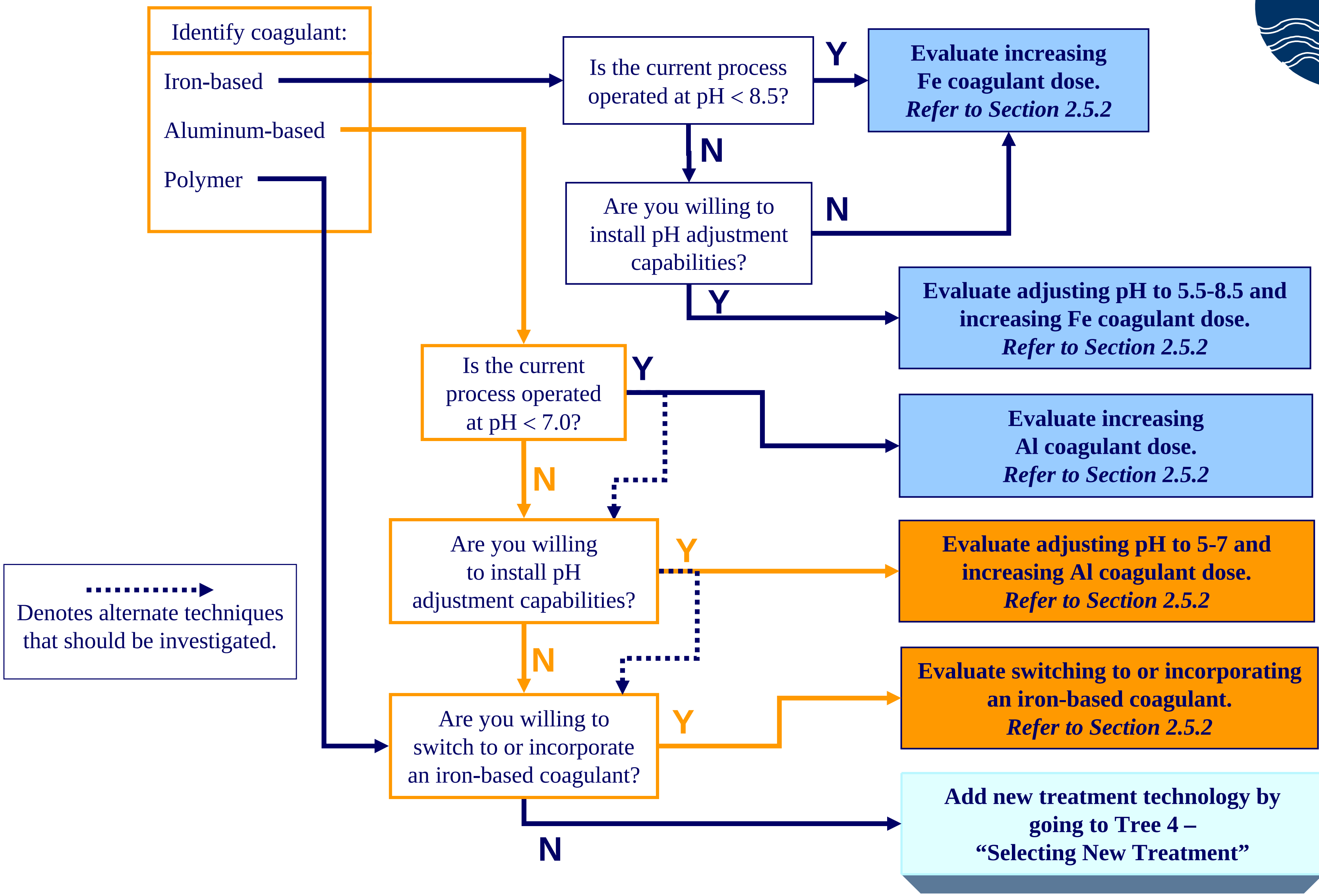
Tree 1
Non-Treatment Alternatives



Tree 2
Treatment Selection



Tree 2a
Enhanced Coagulation/Filtration



Facility B – Ground water facility with chlorination and greensand filtration, gravity storage

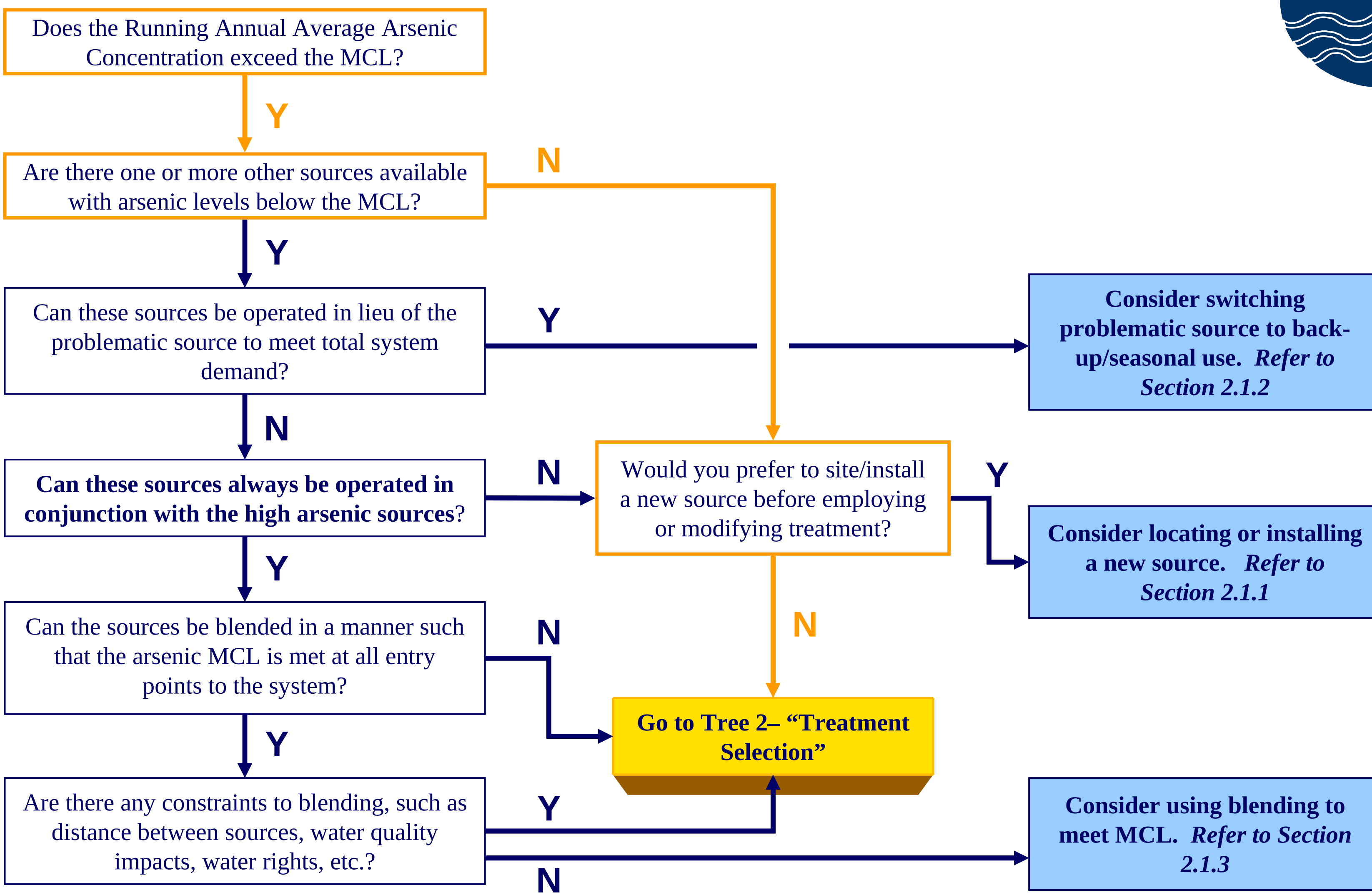
Population – 650

Maximum Daily Flow – 0.2 MGD: 3 wells – 1 plant

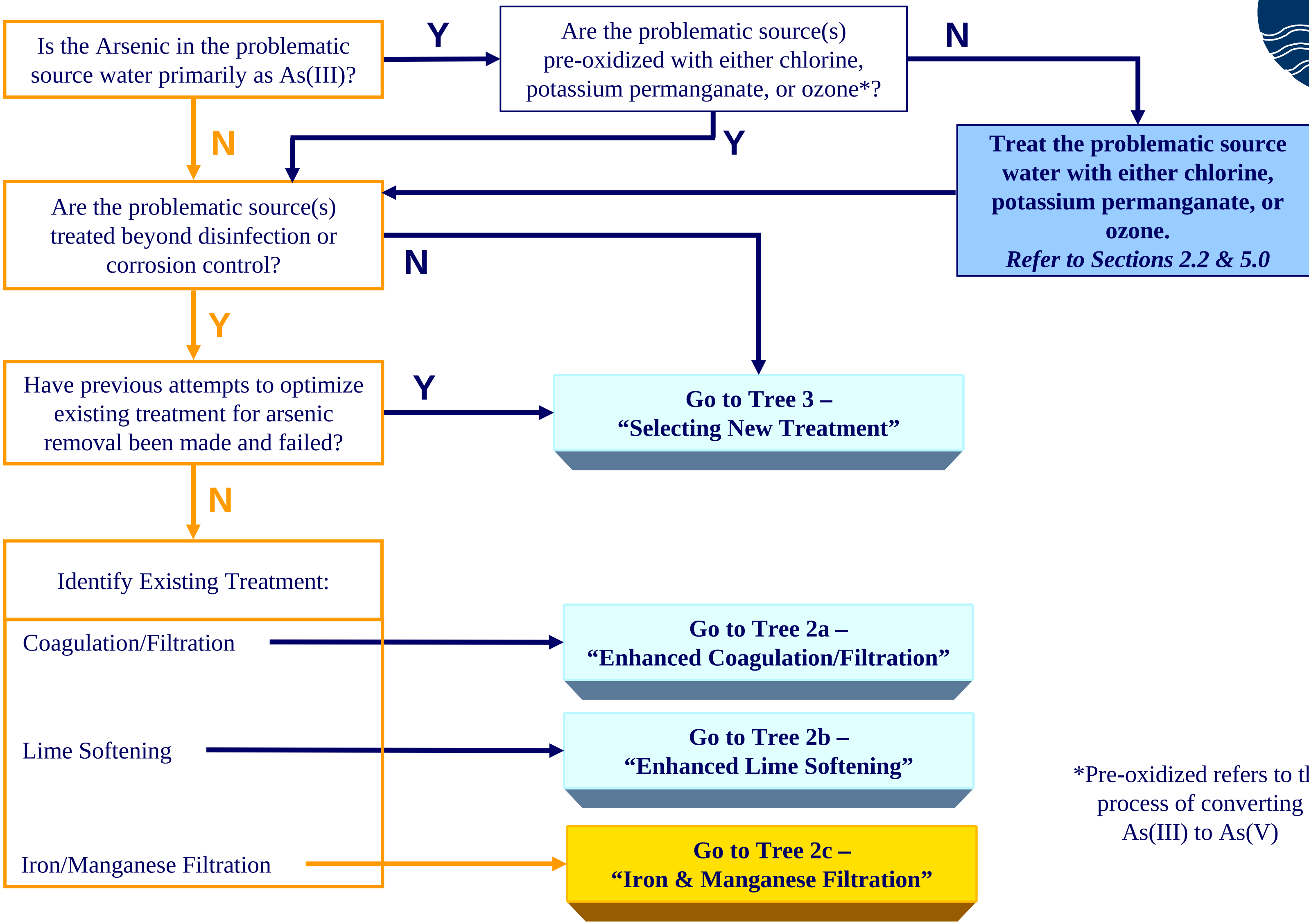
WQ Parameter	Value		WQ Parameter	Value
As µg/L – Total	30		NO_3 mg/L	4
As µg/L – V	20		NO_2 mg/L	<1
pH su	8.1		TOC mg/L	na
SO_4 mg/L	110		Si mg/L	10
Fe mg/L	0.4		Cl mg/L	45
Mn mg/L	0.2		F mg/L	0.4
TDS mg/L	na		Alk – $CaCO_3$ mg/L	175

Misc: POTW discharge available, TBLLs imposed, landfill will not accept hazardous material, filtration facility has excess capacity

Tree 1
Non-Treatment Alternatives

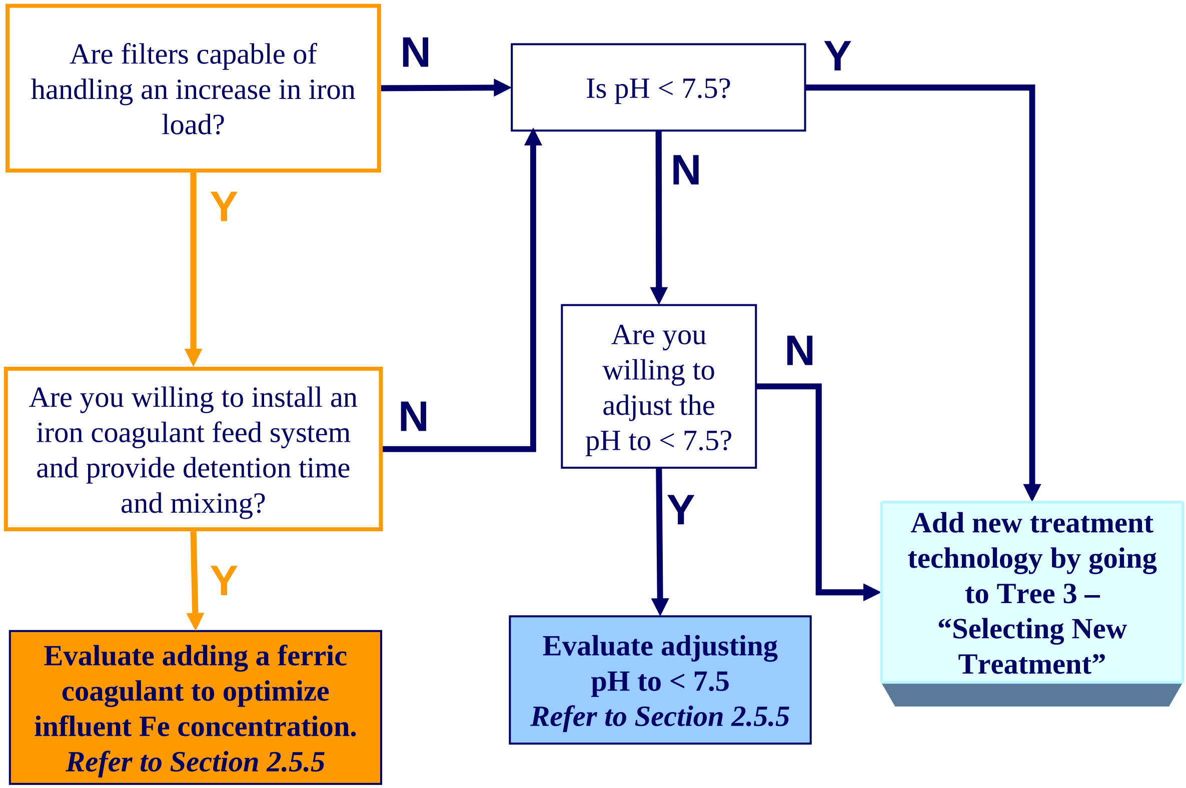


Tree 2
Treatment Selection



*Pre-oxidized refers to the process of converting As(III) to As(V)

Tree 2c
Iron & Manganese Filtration



Facility C – Ground water – Two wells discharging to a common header, one entry point, gravity storage

Population – 600 Maximum Daily Flow – 0.2 MGD

Well #1 – Maximum capacity 200 gpm

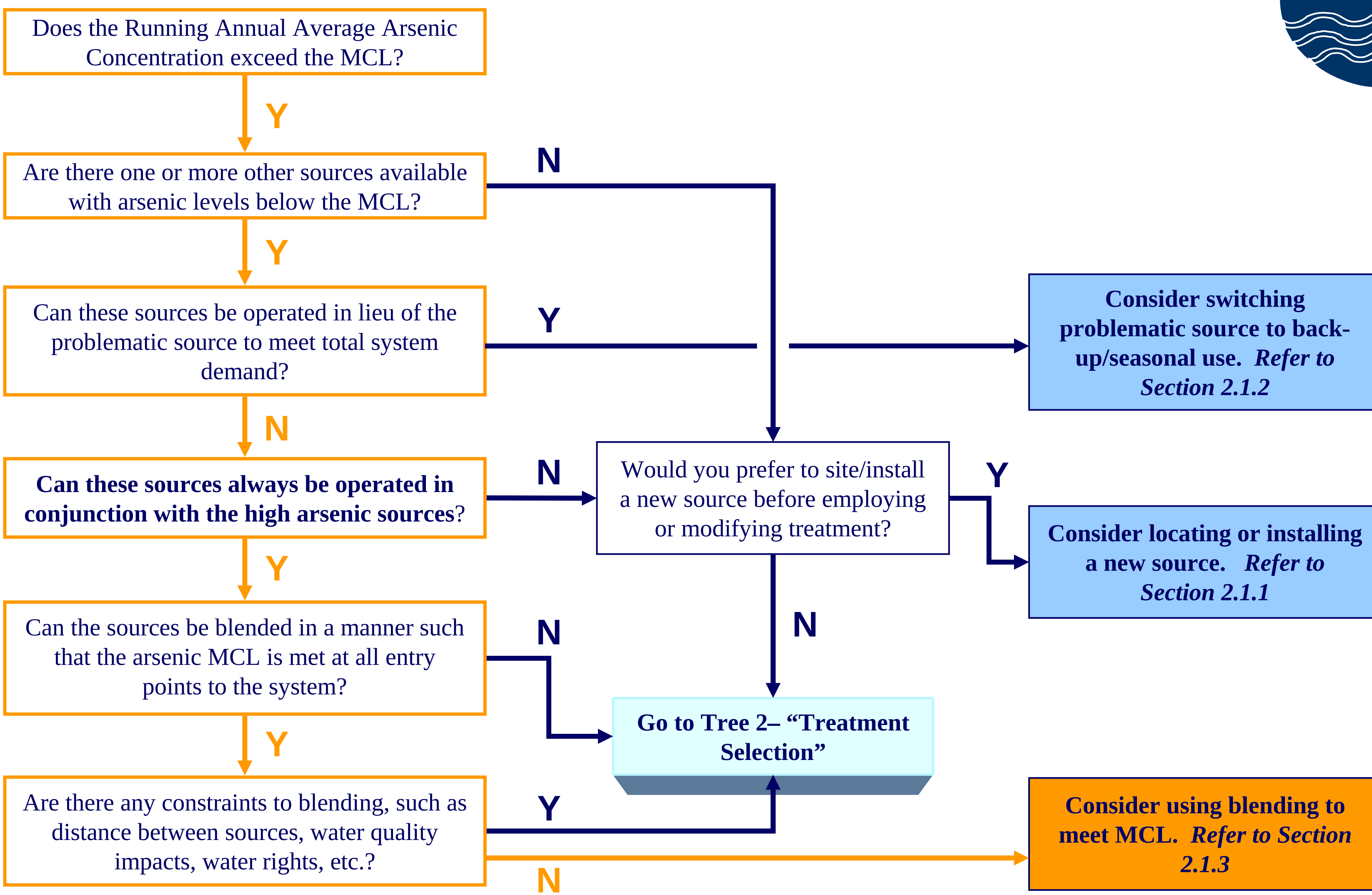
WQ Parameter	Value		WQ Parameter	Value
As µg/L – Total	15		NO_3 mg/L	6
As µg/L – V	5		NO_2 mg/L	na
pH su	8		TOC mg/L	na
SO_4 mg/L	45		Si mg/L	na
Fe mg/L	0.1		Cl mg/L	na
Mn mg/L	<0.01		F mg/L	na
TDS mg/L	na		Alk – $CaCO_3$ mg/L	na

Well #2 – Maximum capacity 100 gpm

WQ Parameter	Value		WQ Parameter	Value
As µg/L – Total	5		NO_3 mg/L	na
As µg/L – V	4		NO_2 mg/L	na
pH su	8		TOC mg/L	na
SO_4 mg/L	45		Si mg/L	na
Fe mg/L	0.1		Cl mg/L	na
Mn mg/L	<0.01		F mg/L	na
TDS mg/L	na		Alk – $CaCO_3$ mg/L	na

Misc: POTW discharge available, TBLLs imposed, landfill will not accept hazardous material

Tree 1
Non-Treatment Alternatives



Facility D – Ground water facility with no treatment

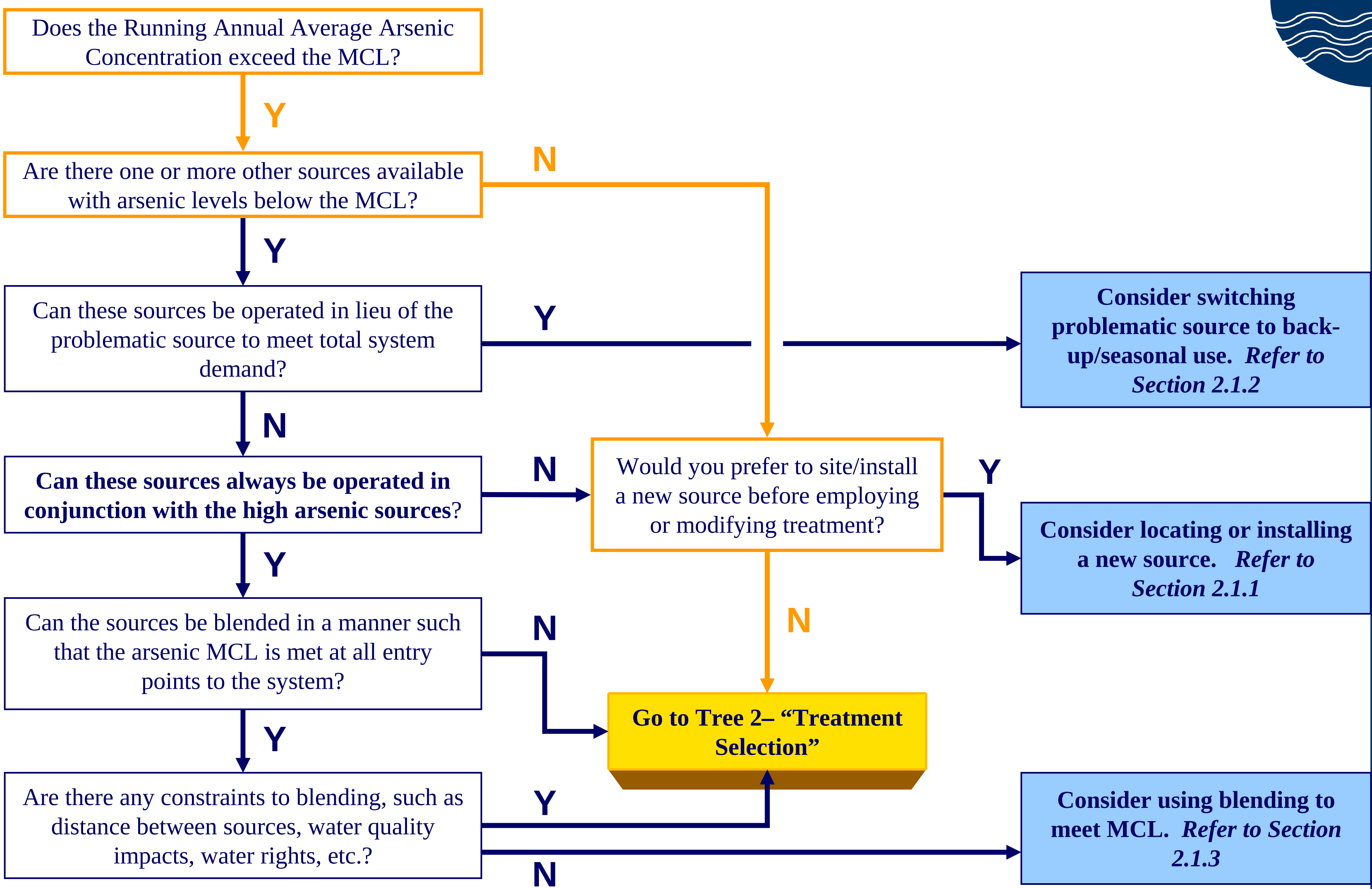
Three wells discharge to common header, gravity storage

Flow – 0.5 MGD

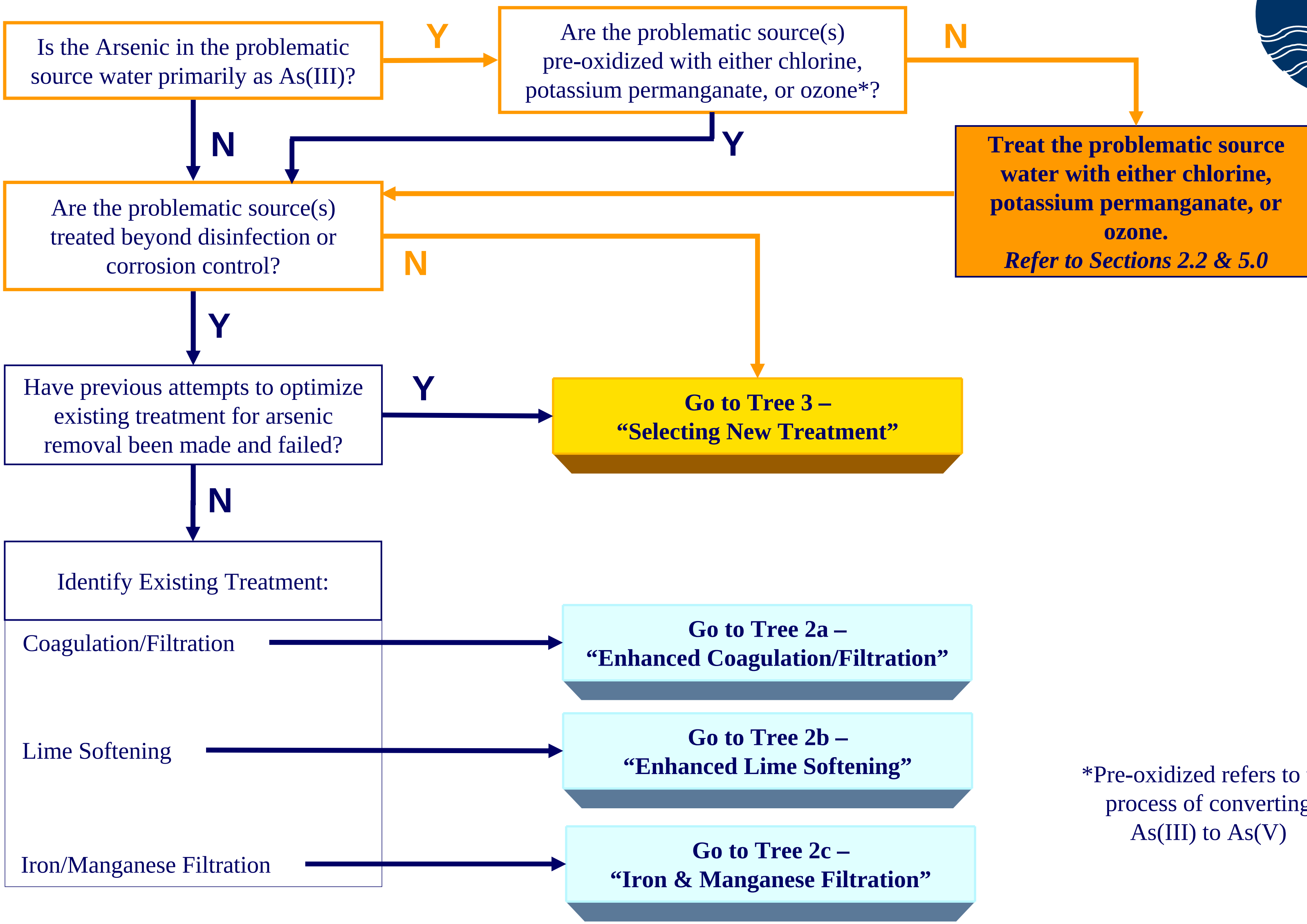
WQ Parameter	Value		WQ Parameter	Value
As µg/L – Total	42		NO_3 mg/L	3
As µg/L – V	12		NO_2 mg/L	<1
pH su	8		TOC mg/L	<0.1
SO_4 mg/L	115		Si mg/L	5
Fe mg/L	0.25		Cl mg/L	30
Mn mg/L	<0.05		F mg/L	0.2
TDS mg/L	365		PO_4 mg/L	0.04

Misc: POTW discharge available, TBLLs imposed, landfill will not accept hazardous material

Tree 1
Non-Treatment Alternatives

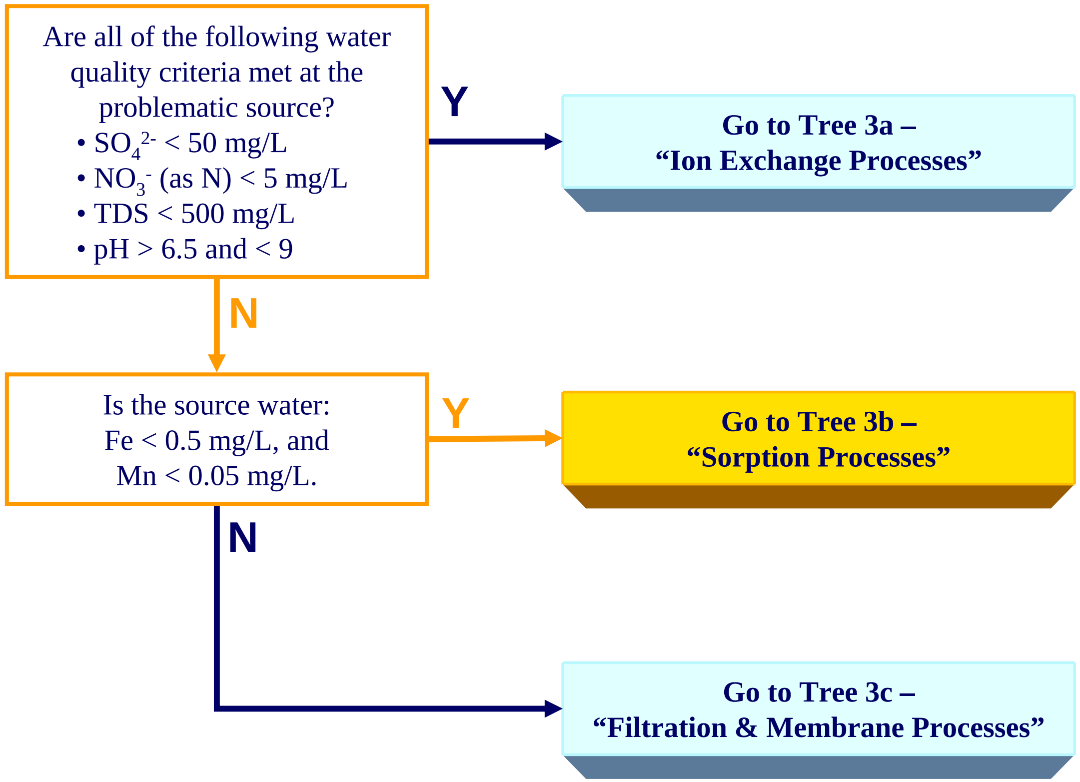


Tree 2
Treatment Selection

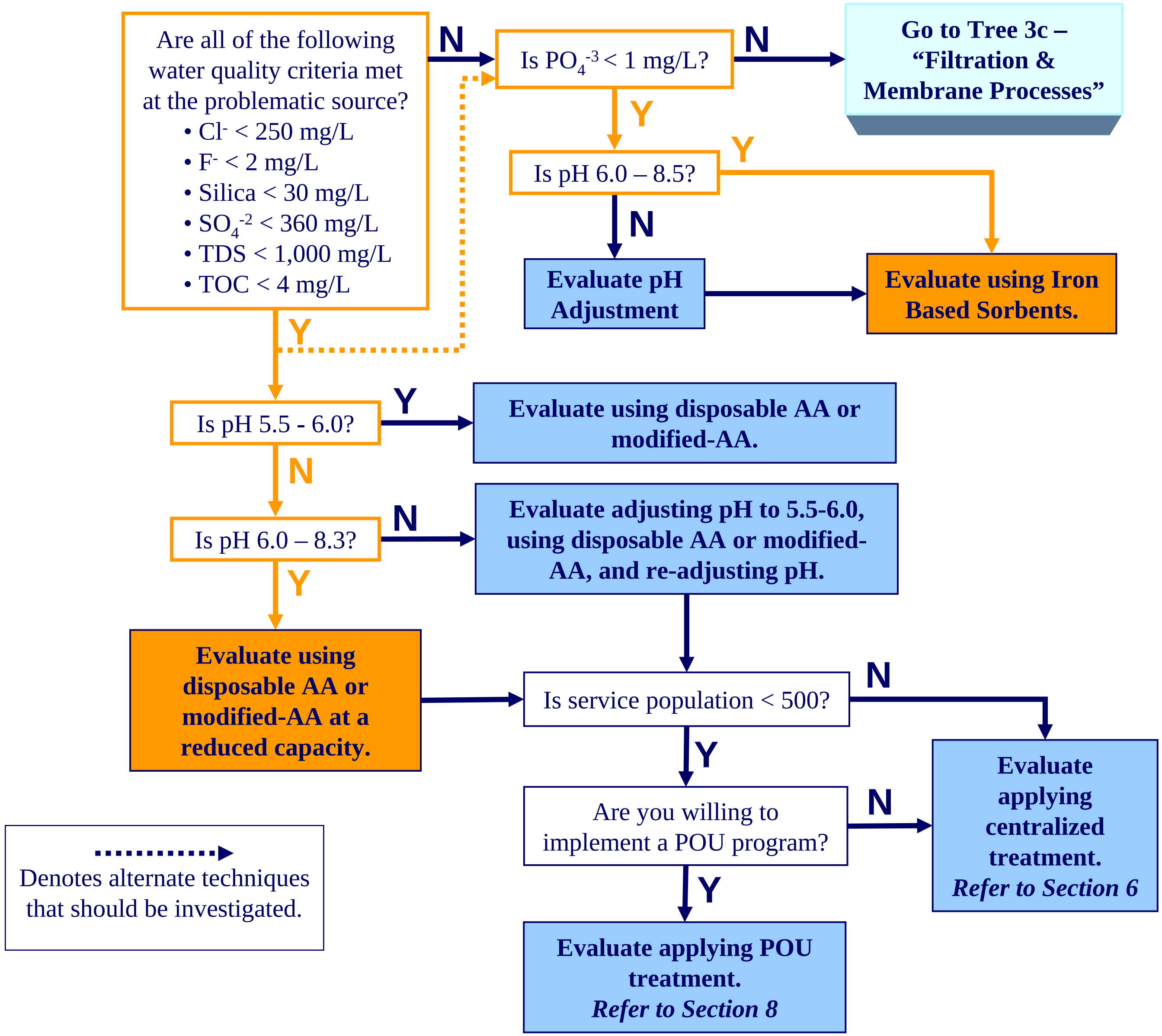


*Pre-oxidized refers to the process of converting As(III) to As(V)

Tree 3
Selecting New Treatment



Tree 3b
Sorption Processes



Facility E – Ground water facility with chlorination, hydro-pneumatic tanks

Population – 150

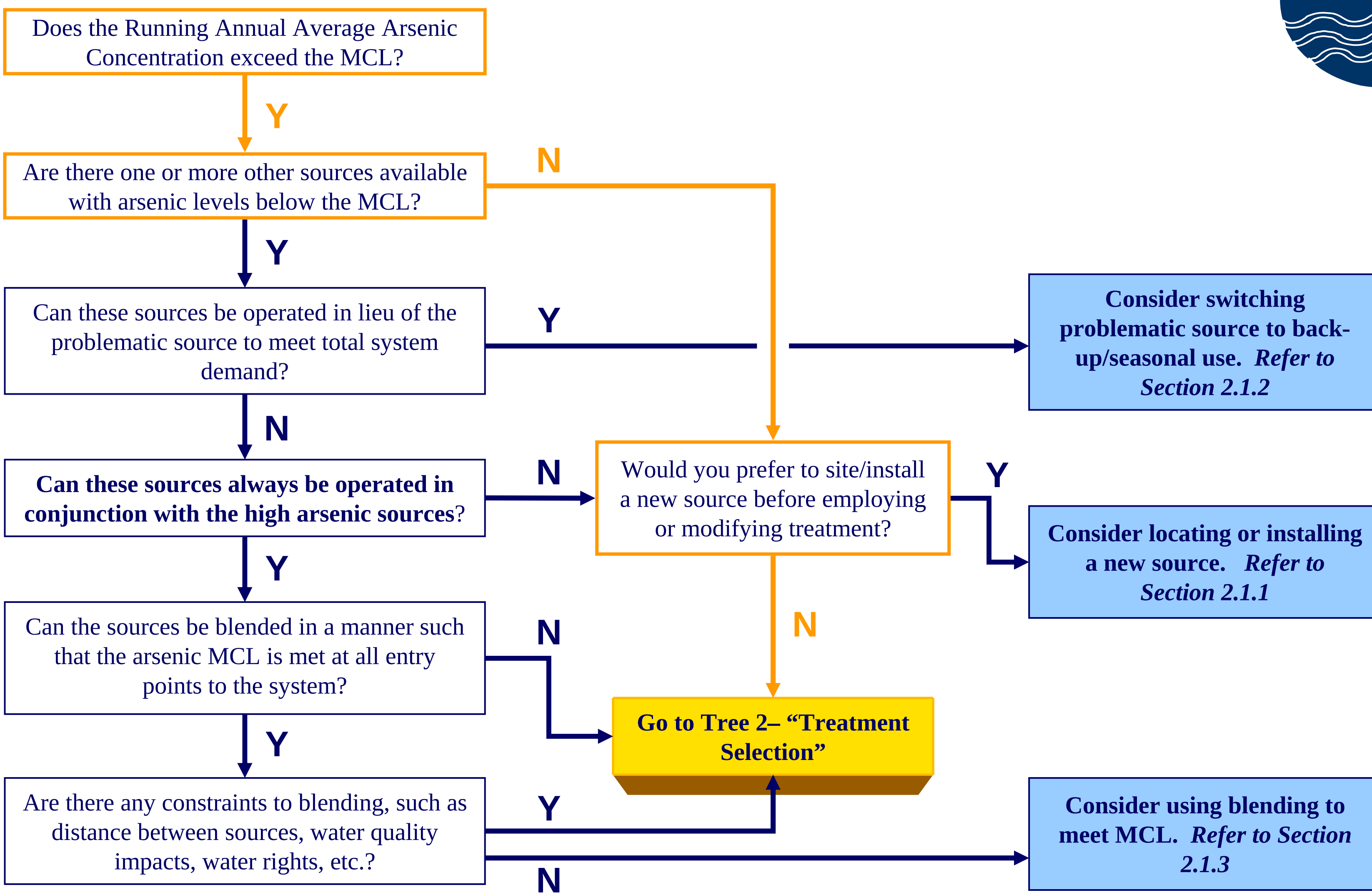
Maximum Daily Flow – 45,000 gal/day: 2 wells (each 30 gpm pumps)

2 entry points – ½ mile apart

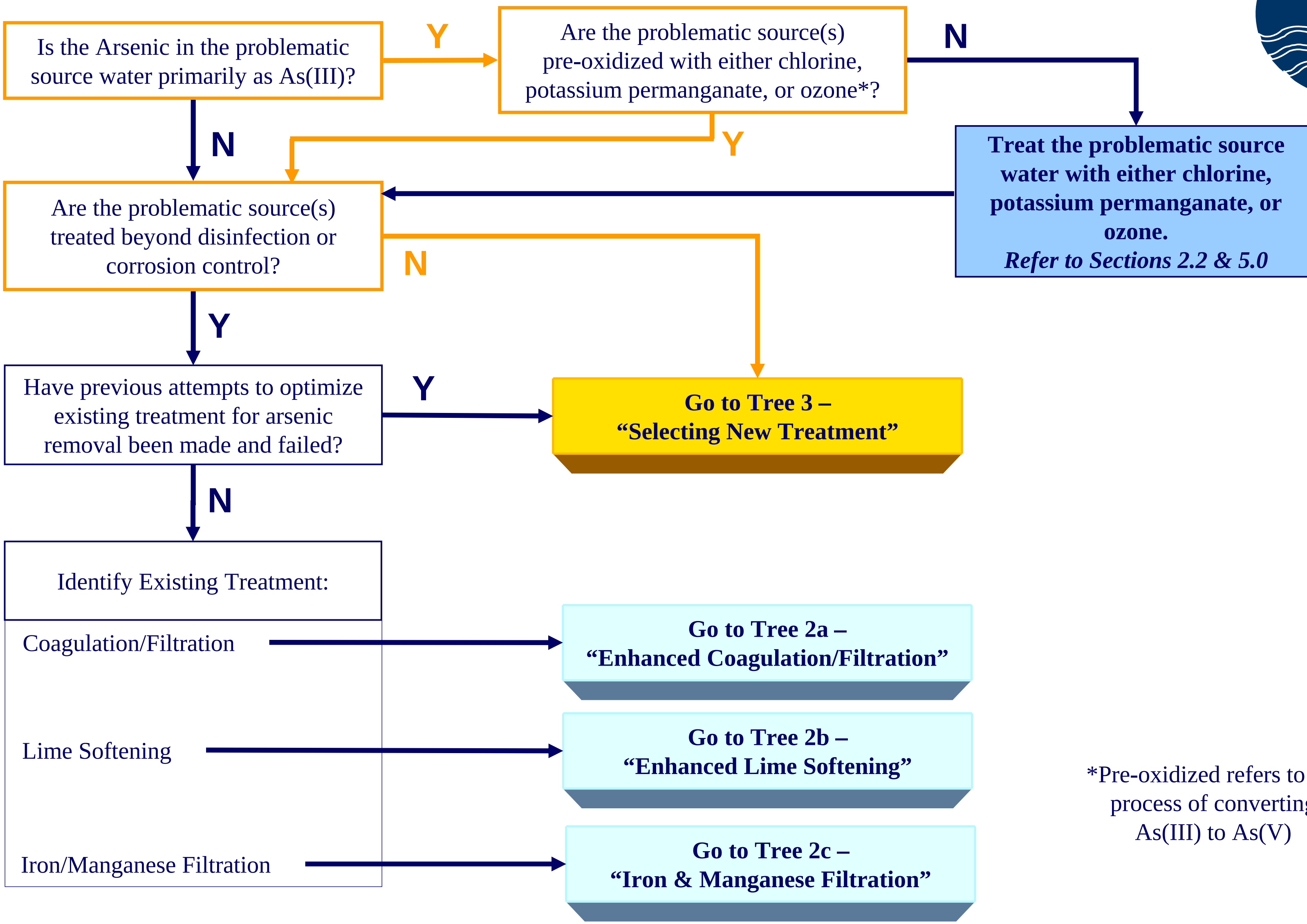
WQ Parameter	Value		WQ Parameter	Value
As µg/L – Total	42		NO_3 mg/L	2
As µg/L – V	12		NO_2 mg/L	<1.0
pH su	8		TOC mg/L	<0.1
SO_4 mg/L	280		Si mg/L	
Fe mg/L	0.6		Cl mg/L	36
Mn mg/L	0.04		F mg/L	
TDS mg/L	840		Alk – $CaCO_3$ mg/L	188

Misc: POTW discharge NOT available, landfill will not accept hazardous material, water quality same for both wells

Tree 1
Non-Treatment Alternatives



Tree 2
Treatment Selection



*Pre-oxidized refers to the process of converting As(III) to As(V)

Tree 3
Selecting New Treatment

Are all of the following water quality criteria met at the problematic source?

- SO_4^{2-} < 50 mg/L
- NO_3^- (as N) < 5 mg/L
- TDS < 500 mg/L
- pH > 6.5 and < 9

Y → **Go to Tree 3a – "Ion Exchange Processes"**

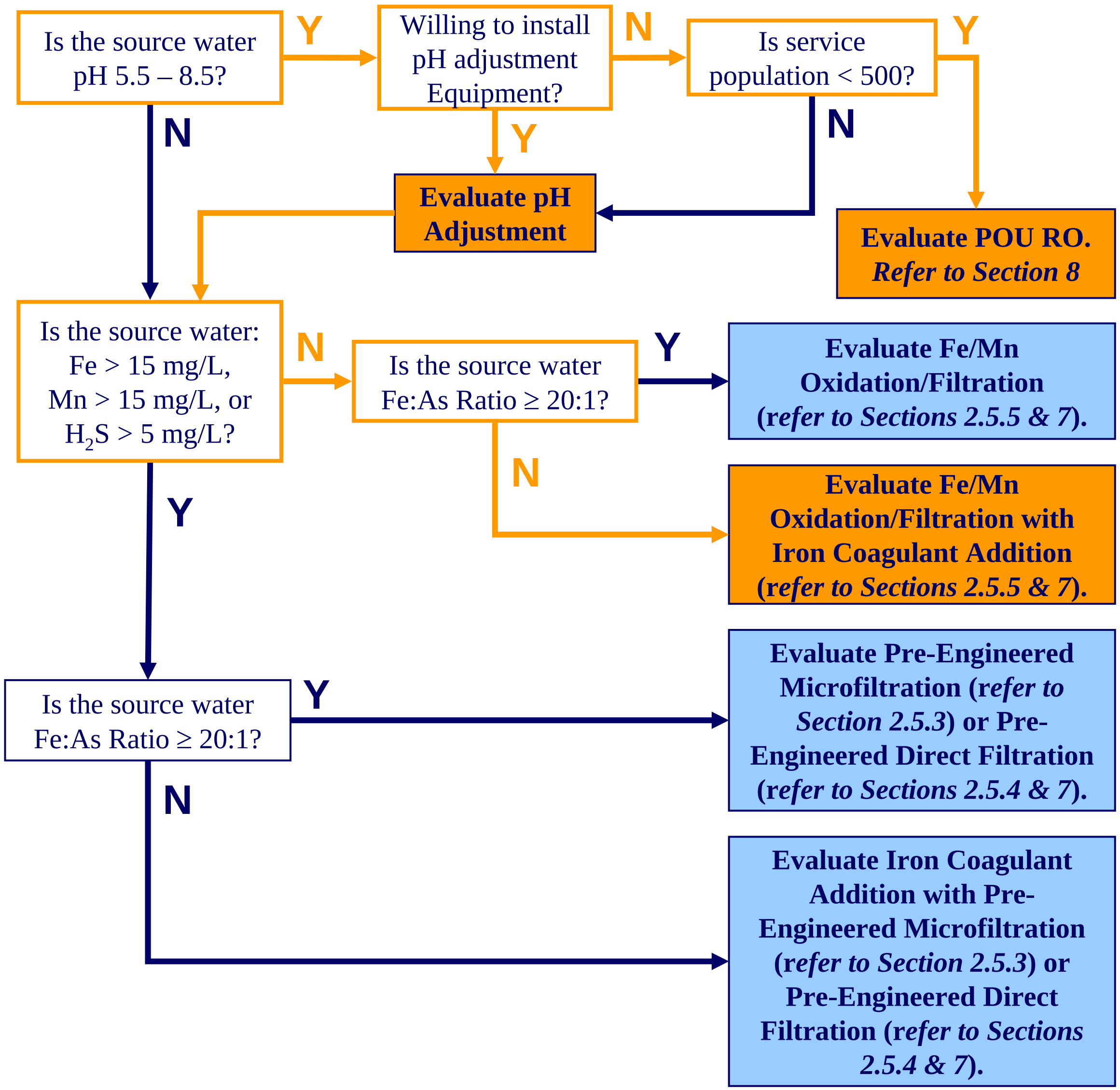
N ↓

Is the source water: Fe < 0.5 mg/L, and Mn < 0.05 mg/L.

Y → **Go to Tree 3b – "Sorption Processes"**

N → **Go to Tree 3c – "Filtration & Membrane Processes"**

Tree 3c
Filtration & Membrane Processes



Facility F – Ground water facility with no treatment

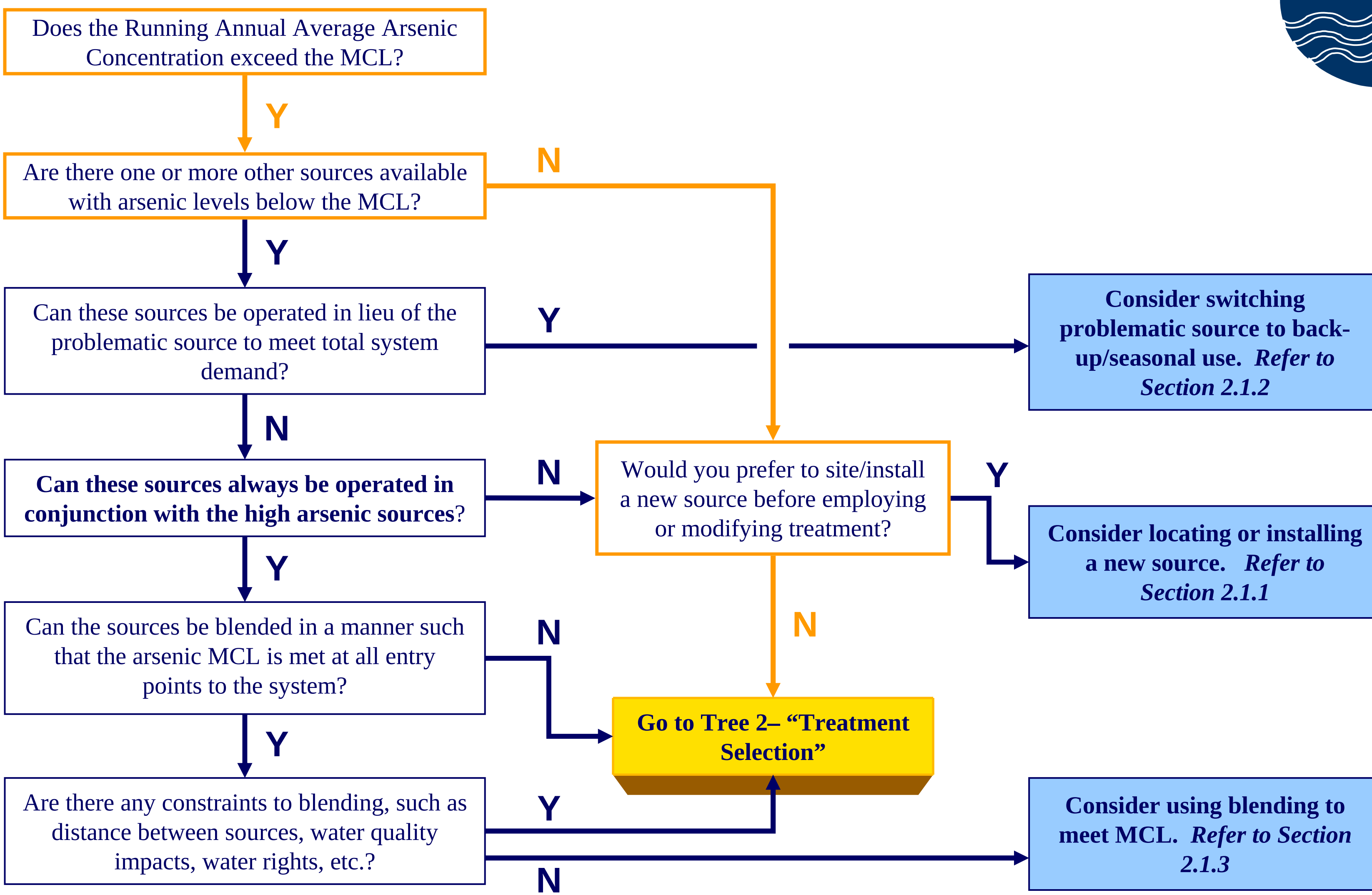
Private school – 300 students and staff – est. 25 gpcd

Maximum Daily Flow – 20,000 gallons/day

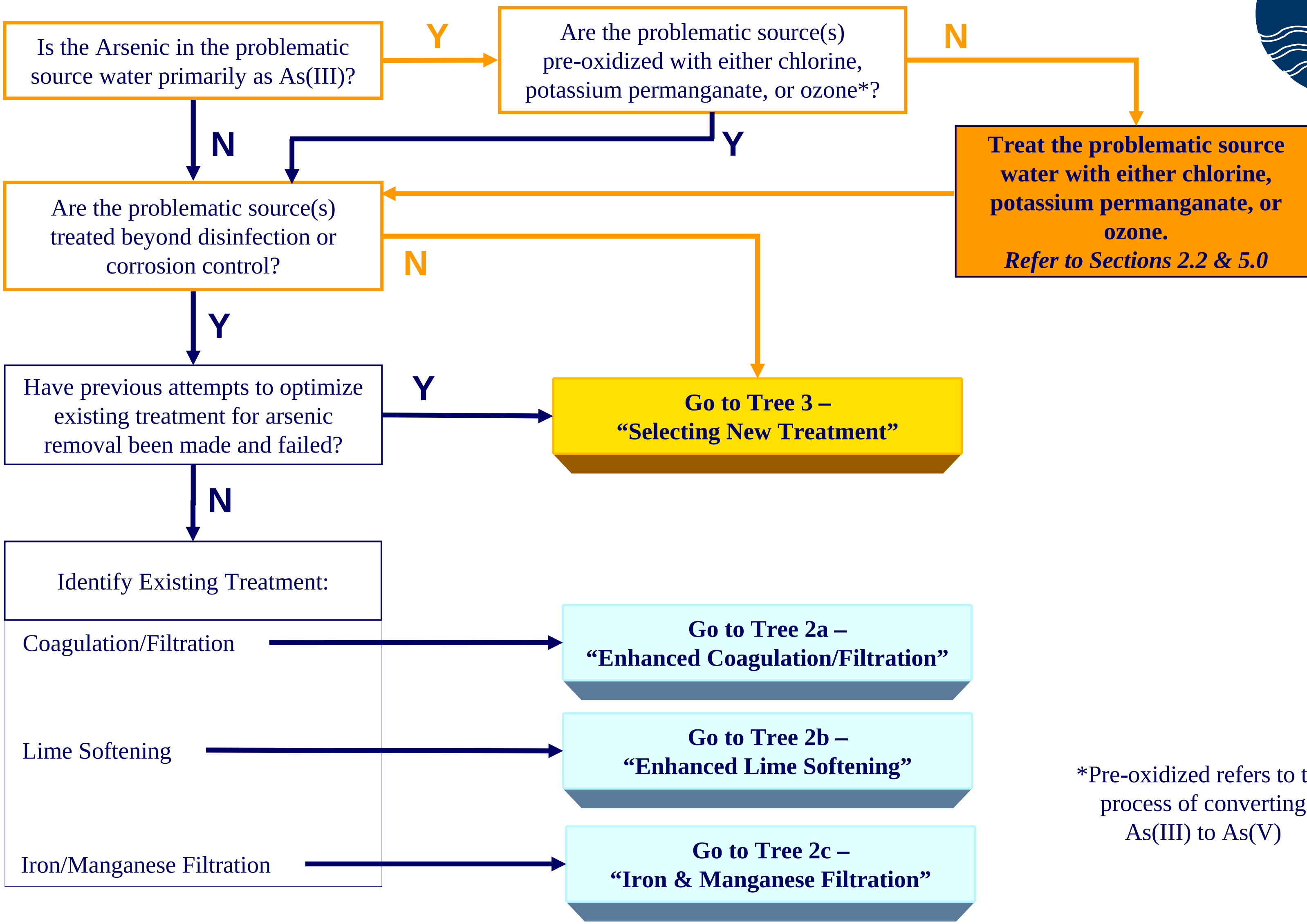
WQ Parameter	Value		WQ Parameter	Value
As µg/L – Total	27		NO_3 mg/L	2
As µg/L – V	8		NO_2 mg/L	<1
pH su	7.4		TOC mg/L	<1
SO_4 mg/L	120		Si mg/L	8
Fe mg/L	0.1		Cl mg/L	27
Mn mg/L	<0.05		F mg/L	1
TDS mg/L	750		Alk – $CaCO_3$ mg/L	220
PO_4 mg/L	<1			

Misc: POTW discharge NOT available, landfill will not accept hazardous material

Tree 1
Non-Treatment Alternatives

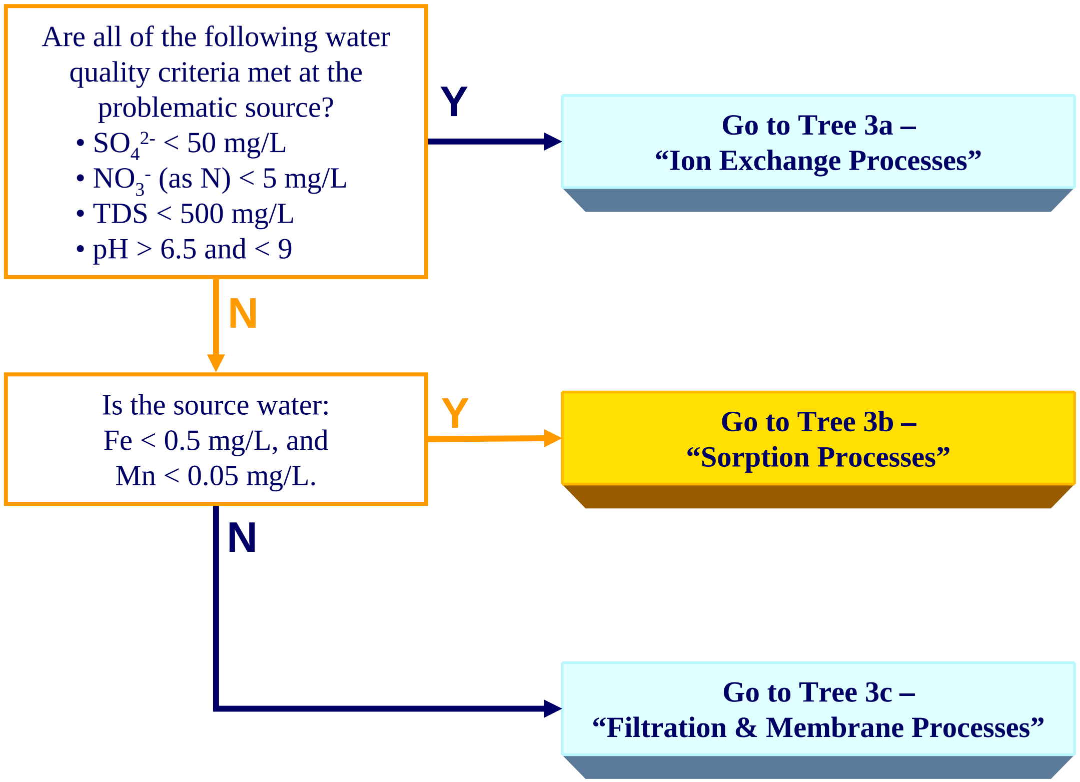


Tree 2
Treatment Selection

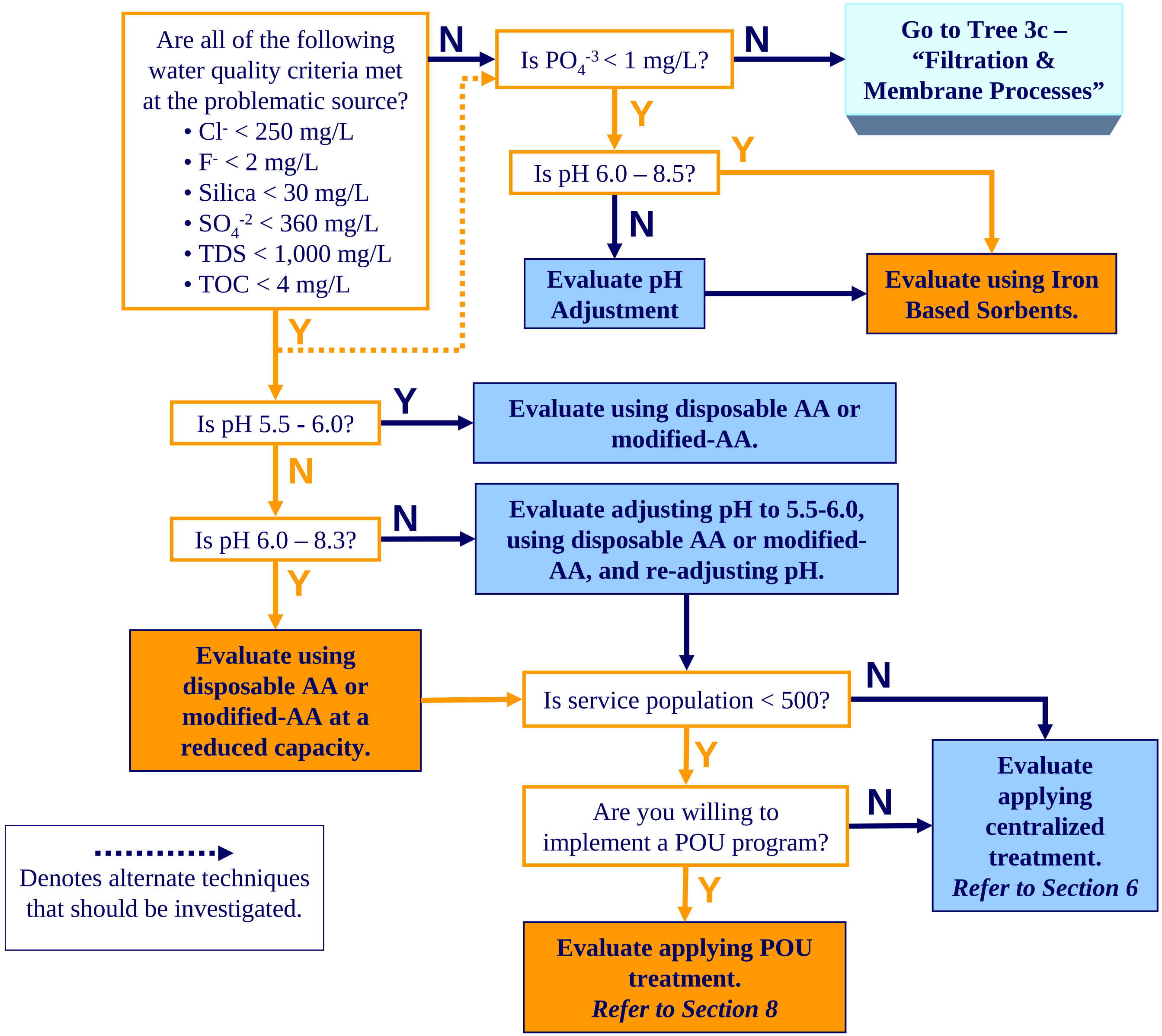


*Pre-oxidized refers to the process of converting As(III) to As(V)

Tree 3
Selecting New Treatment



Tree 3b
Sorption Processes



Waste Disposal

Impacts on Disposal Alternatives

- Concentration of contaminants in the waste stream
  - Non-Hazardous Waste
  - Hazardous Waste
  - Mixed Waste
- Federal, State, & Local Regulations
  - Disposal facility policies
- Type of residuals
  - Liquid
  - Solid

Disposal

Liquid Residuals Brine, Backwash Water, Rinse Water, Acid Neutralization Water, Concentrate			
Disposal Option	Waste Type	Applicable Authority	Key Considerations
Discharge directly to surface waters	Non-hazardous	CWA	•NPDES Permit • Receiving body
Discharge to a Publicly Owned Treatment Works (POTW)	Non-hazardous	CWA	•Meet TBLLs, POTW and state requirements
Injection to a Class 1 UIC Well	Hazardous, Non-hazardous, & Mixed	SDWA/ UIC Regs.	•Expensive, complex, and few wells •Permit required
Injection to a Class V UIC Well	Non-hazardous	SDWA/ UIC Regs.	•Injection prohibited if it will endanger an underground source of drinking water

Disposal

Solid Residuals

Spent Resins, Spent Filter Media, Spent Membranes, Sludge

Disposal Option	Waste Type	Applicable Authority	Key Considerations
Municipal or industrial solid waste landfill	Non-hazardous	RCRA Subtitle D	•No free liquids •At discretion of landfill owner
Hazardous waste landfill	Hazardous & Non-hazardous	RCRA Subtitle C	•No free liquids •Can accept hazardous waste from all generator classes
Low-level Radioactive Waste Landfill	TENORM and possibly Mixed Waste	AEA or Agreement State	•Limited number of landfills in the nation

Intermediate Processing

- Evaporation ponds
- Settling basins
- Sludge drying beds
- Mechanical dewatering

Intermediate processing methods each creating its own residual stream

Intermediate Processes

Some intermediate streams may be classified as hazardous wastes creating a hazardous waste generator classification and a hazardous waste treatment facility!!!

RCRA Land Disposal

- Options:
  - Landfill, land application
- May require permit
- Must be non-hazardous or RCRA land disposal restrictions apply

Residuals Management under CWA

- Direct Discharge
- Discharge to a Publicly Owned Treatment Works (POTW)
- Land Application/Beneficial Reuse
  - Spray Irrigation

Direct Discharge - NPDES

POTW Discharge

Arsenic TBLLs

Albuquerque, New Mexico	**51 µg/L**
Anchorage, Alaska	**3,700 µg/L**
Boston, Mass. (Clinton Sewerage Area, MWRA)	**1,000 µg/L**
Boston, Mass. (Metropolitan Sewerage Area)	**500 µg/L**
El Paso, Texas	**170 µg/L**
King County (Seattle), Washington	**4,000 µg/L**
Lakeland, Florida	**120 µg/L**
Newark, New Jersey	**150 µg/L**
Orange County, California	**2,000 µg/L**
San Jose, California	**1,000 µg/L**

Land Application

- 503 Sludge Regs:
- As concentration 41 mg/kg – designated clean
- As concentration >41 mg/kg – limited to 41 kg/hectacre

SDWA-UIC Background

The Safe Drinking Water Act (SDWA) Underground Injection Control (UIC) program

- Established to protect the quality of drinking water in the U.S.
- Prohibits movement of injected fluids into underground sources of drinking water

Conventional WTP Residual Disposal

- **Solid wastes**
  - Solids from the sedimentation basin (blowdown)
  - Media from filters
  - Dewatered sludge's
- **Liquid wastes**
  - Backwash water

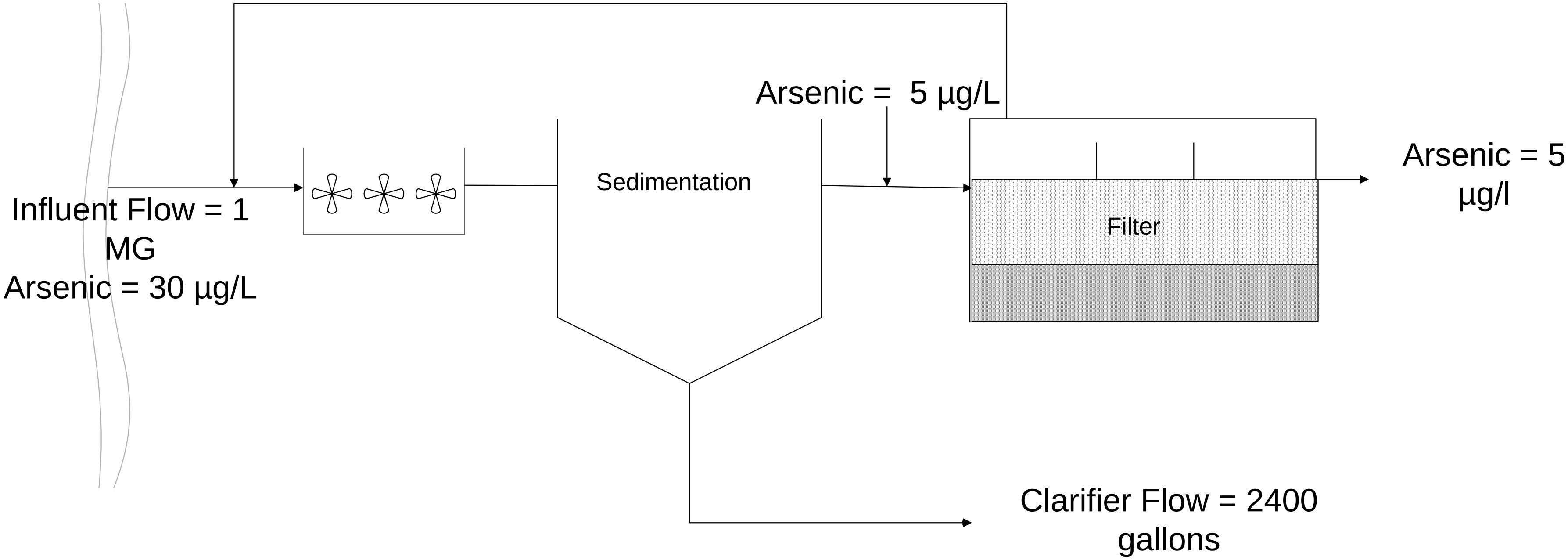
Disposal Example

Conventional WTP Residual Disposal

- Clarifier sludge ~0.5%
- Clarifier sludge arsenic concentration ~10 mg/L
- Sludge arsenic concentration ~2000 mg/kg dry weight
- Water treated is 1 MG – Clarifier sludge flow is 2400 gallons
- Treatment reduces As from 30μg/L to 5μg/L
- Filter backwash water solids are negligible.

What Disposal Options are Available?

Conventional WTP



Clarifier Sludge Disposal?

- Direct Discharge?
- Discharge to the Sanitary Sewer?
- Land Application – if so at what rate and how many acres?
- Landfill? Any Conditions
- Hazardous Waste Facility?

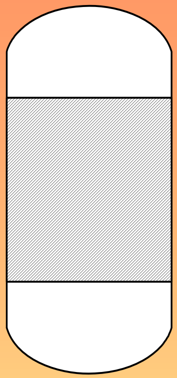
Conventional WTP Residual Disposal

Disposal Method	Option Available?
Discharge to receiving stream	
Discharge to sanitary sewer	
Land Application	
Landfill	
Hazardous waste facility	

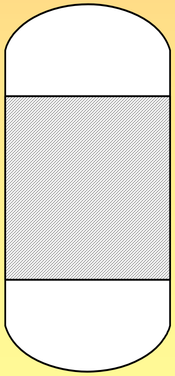
Conventional WTP Residual Disposal

Disposal Method	Option Available?
Discharge to receiving stream	**No**
Discharge to sanitary sewer	**Not likely**
Land Application	**Possible but has limits**
Landfill	**Yes**
Hazardous waste facility	**Only if needed**

Media Evaluation Exercise



Media A
EBCT = 5 minutes
Cost = $200 / cu. Foot
Capacity = 35,000 BV
TCLP = pass
As Removal = 95%



Media B
EBCT = 5 minutes
Cost = $300 / cu. Foot
Capacity = 50,000 BV
TCLP = pass
As Removal = 95%

Media Evaluation

- **First, evaluate Media A:**
- **Total media cost = V (ft3) x $200/ft3**
- **The cost per bed volume (BV) = (V x $200) / (35,000 BV)**
- **= $0.0057 per BV**
- **Next, evaluate Media B:**
- **Total media cost = V (ft3) x $300/ft3**
- **The cost per bed volume (BV) = (V x $300) / (50,000 BV)**
- **= $0.0060 per BV**
- **The cost of Media A is slightly cheaper than Media B.**